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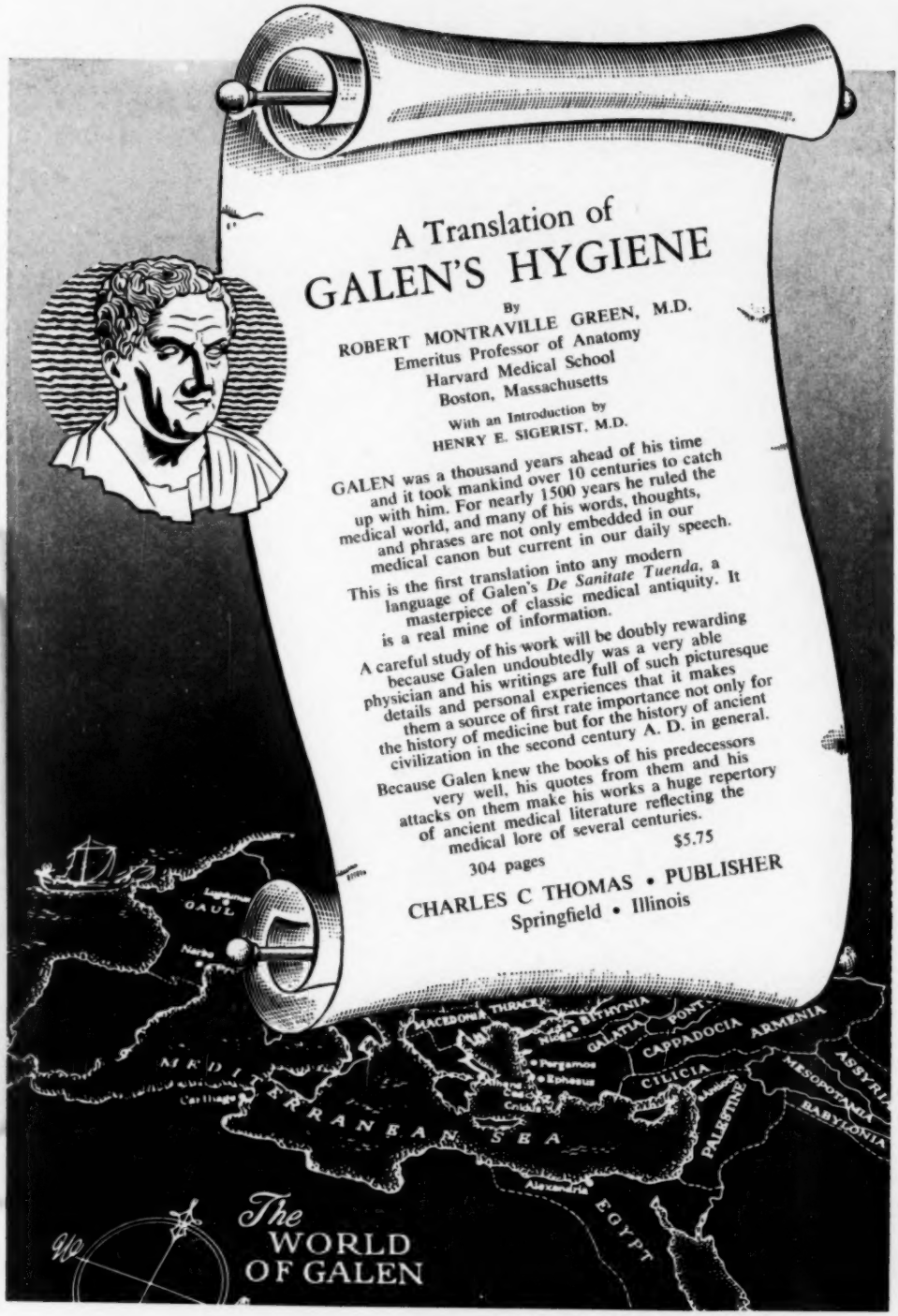
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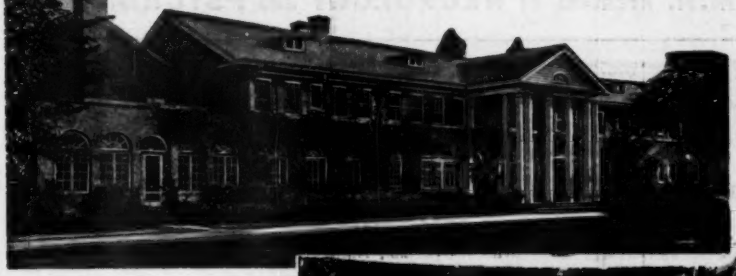

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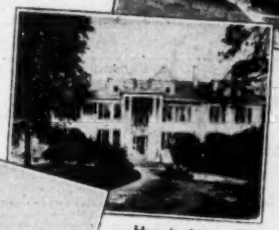

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VOLUME 66 NOVEMBER 1951 NUMBER 5

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SPASTICITY, PSEUDOSPONTANEOUS SPASMS, AND OTHER REFLEX ACTIVITIES LATE AFTER INJURY TO THE SPINAL CORD

LEWIS J. POLLOCK, M.D.
BENJAMIN BOSHES, M.D.
ISIDORE FINKELMAN, M.D.
HERMAN CHOR, M.D.
AND
MEYER BROWN, M.D.
CHICAGO

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Disappearance of reflex activities formerly held as characteristic of complete section of the spinal cord

X. SUMMARY

INTRODUCTION

DURING World War I, an opportunity was afforded to observe the reflex activity of the distal segment of a transected or severely injured spinal cord. Reports upon such observations were made at variable, but relatively short, times after injury. These reports disproved the so-called Bastian law. Furthermore, they led to the conception of an evolution of change in reflex activity of the distal segment of a severed spinal cord which included three stages. The first was that of areflexia; the second, that of return of reflex activity, and the third, that of disappearance of the reflex activities.

It was held that soon after reflex activities were reorganized the evidence adduced from the posture and type of reflex activity served to differentiate the completely severed spinal cord from the cord with less severe injury. Paraplegia in flexion was found to be characteristic of complete lesions, and paraplegia in extension, of incomplete lesions. Attention was also called to a characteristic concomitance of other responses, consisting of a flexor withdrawal, excessive sweating below the level of the lesion, and automatic emptying of the bladder. This was designated as a mass reflex. However, because of the relatively early death of the patients so injured, there was no opportunity to observe the later changes which might have occurred.

As the result of the use of antibiotics and of improved surgical and nursing procedures, men who sustained injuries to the spinal cord in World War II have survived in large numbers to the present time. The study of these veterans has resulted in conclusions some of which differ from those reached from the studies on men wounded in World War I.

Our studies began in the middle of 1946 and are being continued by us and a staff of house officers. A number of analyses of data obtained continuously from these veterans constitute the basis of this report. About 300 veterans suffering from injuries to the spinal cord and cauda equina are in constant residence in the medical wards of the United States Veterans Hospital at Hines, Ill. The medical neurological service is responsible for their care and treatment. In addition, the surgical neurological service is responsible for the patients with current acute injuries and those with old injuries which require surgical treatment, such as rhizotomy, exploration or chordotomy. These patients are transferred to the neurosurgical service, which has available an additional 75 beds.

Since the population moves because of discharges, deaths, and admissions at any one time an analysis made upon a certain number of injured patients included in part a number substituted for others who had departed. This made possible comparisons of data obtained from different samplings and served to support our conclusions.

This study was aided by a grant from the United States Veterans Administration.

From the Department of Nervous and Mental Diseases, Northwestern University Medical School.

Read by title at the Seventy-Third Annual Meeting of the American Neurological Association, Atlantic City, N. J., June 14-16, 1948.

Reviewed in the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the authors are the results of their own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

POSTURE

The posture assumed by the patients could be classified as paraplegia in flexion and paraplegia in extension. When in extension, some had associated spasticity of muscles; others, none. The posture was found to be unrelated to the severity of the lesion, but at earlier times after injury there was a correlation with the level of the lesion. As time progressed, there was a change in posture in many of the patients from one in flexion to one in extension.

An analysis of posture was made in 1946 upon 213 patients; in 1948 upon 175 patients, and six months later upon 94 patients. In 1946, paraplegia in flexion was found in 38.5% of 26 patients with lesions of the cervical portion of the spinal cord, in 26% of 146 patients with lesions of the thoracic portion, and in 7% of 41 patients with lesions of the lumbar portion. In 1948, paraplegia in flexion was found in 47% of 23 patients with lesions of the cervical portion, in 33.5% of 112 patients with lesions of the thoracic portion, and in 12% of patients with lesions of the lumbar portion. This posture was definitely related to the level of the lesion, and the incidence diminished as the level descended. Even at the last analysis, when the posture of many of the patients had changed from one in flexion to one in extension, the same relationship was found; at this time a flexor position was found in 15.4% of patients with lesions of the cervical portion, in 11% of patients with lesions of the thoracic portion, and in 6% of patients with lesions of the lumbar portion of the spinal cord.

On the contrary, paraplegia in extension was found in greater numbers of patients as the level of the injury descended. Paralysis in extension was at times associated with spasticity of muscles; at times, not. In the latter case the paralysis was found chiefly with injuries of the lumbar portion of the spinal cord, being noted in 70% in 1946, 66% in 1947, and 13.3% in 1948.

However, in 1947, paralysis in extension without spasticity in muscles was found in 18% each of lesions of the cervical portion of the spinal cord and of the 1st to the 9th thoracic segments and in 57% of lesions of the 9th to the 12th thoracic segment, inclusive, of the spinal cord. Later, spasticity again developed in these patients, so that, in 1948, 27% had no spasticity and 59% possessed spasticity. As the posture changes from one in flexion to one in extension, the muscles at first do not exhibit spasticity, but later do. It would seem that in the case of lesions of the cervical portion of the cord the onset of spasticity is delayed, since when, in 1948, the percentage of patients with paraplegia in flexion had dropped from 47 to 15 the percentage of patients with paraplegia in extension and spastic muscles remained unchanged, but when the paraplegia was unassociated with spasticity the percentage rose from 13 to 41. Unfortunately, we do not have data on the further course of the disease in these patients.

Owing to the high mortality in injuries of the spinal cord sustained in World War I, there was an opportunity to confirm total transections of the spinal cord by histopathological studies. The far lower mortality in World War II has made it almost impossible to confirm the presence of such lesions.

It becomes necessary to evaluate the completeness of a lesion by the description of the gross pathology found when the injured spinal cord was explored. Although at times an unequivocal severance of the cord may have been recorded, often the condition has been described by other terms, such as "the cord is pulpified" or "the

proximal and distal portions of the injured spinal cord were connected only by shreds of tissue." In the latter situation, one is compelled to evaluate the degree of injury by considering the subsequent clinical findings. In the case of lesions which have not been described when explored, one is limited to the subsequent clinical findings alone.

We have assumed the lesion to be physiologically incomplete when there was either conservation or return of motion, sensation, and autonomic functions below the level of a lesion. In such cases the lesion may have been found at exploration to have been anatomically incomplete. The lesion may be presumed to be physiologically complete when there has been no return of function after a long period. The lesion may or may not have been found to be anatomically complete at exploration. When at exploration the spinal cord has been stated to be severed, it may be said that the lesion is an anatomically complete one.

Of 27 patients in whom the spinal cord was found divided at operation, a posture of spastic flexion was found in 2 (lesions at the first and third thoracic segments). In 15 patients there was a posture of extension with spasticity (lesions at 3d, 4th, 5th [5 patients], 6th [2 patients], 7th, 8th, 9th [2 patients], 10th, and 12th thoracic levels, respectively). In nine the posture was that of flaccid extension (lesions at 6th, 7th, 10th, 11th [3 patients] thoracic and 1st lumbar [3 patients], respectively). Paraplegia in flexion occurred in only two patients, both with upper thoracic lesions; extension with spasticity occurred only with the lesion above the 1st lumbar segment, and flaccid extension, chiefly with lesions below the 10th thoracic segment.

When this study of posture was being conducted, there were 15 cases in which return of some function indicated an incomplete lesion. In eight cases the posture was that of extension with spasticity; in five, one of extension without spasticity, and in two one of spastic flexion.

At this long time after injury it did not seem that there was any correlation between the type of posture and the completeness or incompleteness of the lesion.

STRETCH REFLEXES: SPASTICITY; MYOTATIC, PLUCK, AND DEEP REFLEXES

Spasticity, as it is typically seen with cerebral lesions producing hemiplegia, is described as being characterized by an increase over normal of the tension of a muscle, resulting in continuous increase of resistance to stretching of the muscle; at times it results in shortening of the muscle. Usually there are associated increased deep reflexes, at times to the degree of elicitation of clonus and the presence of reflexes normally not observed, such as the Babinski sign. The spasticity here is regarded as the result of an uninhibited stretch reflex.

In our study of injuries of the spinal cord, it was found that, although in a certain proportion of cases spasticity in part, as described above, was present, in others it was absent. When in the latter cases the extremity was carefully handled and such reflex activity as may have been evoked by grasping the extremity had been permitted to subside, relatively slow stretching of the muscles examined did not give rise to increased resistance over normal; in fact, often the resistance was felt to be less. Nevertheless, in a number of these cases it could be seen that the muscles were not entirely flaccid when the patient was recumbent and at rest.

In using the term spasticity, we define it as being demonstrable by a sustained increase in tension over normal when the muscle is passively lengthened. Moreover,

the increase in tension is felt from the beginning of a passive movement. Furthermore, the tension increases in proportion to the extent to which the muscle is lengthened, and no local deformation of the muscle bundle is observable.

In accordance with this definition, at one time 153 cases of severe injury to the spinal cord were analyzed. There were 42 cases of lesions of the cervical portion, 56 cases of lesions of the 1st to the 8th thoracic segments, inclusive, and 55 cases of lesions of the 9th to the 12th thoracic segments, inclusive. Lesions of the lumbar portion of the spinal cord were excluded because spasticity occurred in relatively few cases.

In 83 of 153 cases, or 54%, examination showed spasticity, which, when demonstrated, was not found in all the paralyzed muscles in all cases. It was found in all muscles in many of the cases, and in a few muscles, and in varying numbers, in others; but when spasticity was demonstrated in any muscle the case was included in this category.

There was a definite relation of the level of the lesion to the frequency of spasticity. Spasticity was present in 30 of 42 cases of cervical lesions, or 71%; in 35 of 56 cases of lesions of the 1st to the 8th thoracic segment, inclusive, or 61%, and in 18 of 55 cases of lesions of the 9th to the 12th thoracic segment, inclusive, or 34%.

Although there was a diminishing frequency of cases in which any spasticity was exhibited as the level descended from the cervical region, an estimation of the ratio of muscles in which spasticity could be demonstrated to all muscle groups examined in which spasticity was sought revealed a different distribution. Thus, at another time, 22 patients with injuries to the cervical portion of the cord, 31 patients with injuries to the 1st to the 9th thoracic segment, inclusive, and 26 patients with injuries to the 10th to the 12th thoracic segment, inclusive, were studied. Spasticity was sought in both extremities when the feet were in dorsal and when they were in plantar flexion, when the legs were flexed and when they were extended, and when the thighs were abducted. This resulted in the examination for spasticity of a total of 790 muscle groups in 79 patients.

The percentage of muscle groups in which spasticity was found was 48.1 for lesions of the cervical portion, 51.7 for lesions of the 1st to the 9th thoracic segment, inclusive, and 20.7 for lesions of the 10th to the 12th thoracic segments, inclusive.

Although the percentage of cases with spasticity in which the cervical portion of the spinal cord was injured was greater than that in which the injury was between the 1st and the 9th thoracic segment, inclusive, a greater number of muscles exhibited spasticity when the upper thoracic segments were injured. Patients with lesions in the lower thoracic portion of the spinal cord showed the smallest number of cases and the least extent of spasticity.

We compared the spasticity in 19 cases of incomplete lesions with the spasticity in 22 cases of complete lesions of the cervical portion of the spinal cord. The ratio of the number of muscles with spasticity to the number of muscle groups examined was 48.1% for complete lesions and 31% for incomplete lesions. We were unable to find any correlation between numbers of patients with spasticity and the severity of the lesion. Of 20 patients with verified anatomic section of the spinal cord at various levels, 50% showed spasticity equaling that in the group of 153 patients with only physiologically complete lesions. The percentage of muscle groups in

which spasticity was found was 38.7 for 16 patients with complete section of the spinal cord, again approximating the 39.1% for all the other 79 patients examined.

The "slight constant tension which is the characteristic of the healthy living muscle" has been shown to be dependent upon a tonic spinal reflex. That an increase of sustained tension or spasticity is the result of diminished inhibition of a tonic spinal cord reflex is generally accepted. However, when this reflex, as well as the myotatic reflex, is identified as a stretch reflex in man after injury to the spinal cord, some confusion results.

After Sherrington [1] discovered that decerebrate rigidity disappeared entirely after severing the dorsal nerve roots, Liddell and Sherrington [2] described the stretch, or myotatic, reflex as it occurred in the decerebrate preparation. This type of stretch reflex, or myotatic reflex, is characterized by "two phases, (i) a phasic reaction corresponding with the period of increasing stretch and (ii) a postural reaction corresponding with the period during which the stretch is maintained." [3] In the decerebrate preparation the reflex is found predominantly in the antigravity, or extensor, groups of muscles.

It has been shown that this myotatic reflex is a reaction integrated at the spinal level (Denny-Brown and Liddell [4]; Matthes and Ruch [5]). The reflex has also been observed in decorticate preparations.

In clinical studies it is difficult, if at all possible, to study adequately the myotatic reflex in its relation to spasticity. In both, a sustained increase of resistance to passive lengthening of a muscle is found; attention, however, may be called to certain observations which suggest that, although both may be present, and both elicited by stretch of a muscle, they differ in their mechanism. The myotatic reflex is predominantly found in the antigravity muscles in a decerebrate preparation. If the spasticity resulting from injury to the spinal cord were the result of a similar mechanism, it would be expected that it would be found in the same muscles. In 79 cases of severe injury to the spinal cord with physiologically complete lesions, spasticity as defined by us was sought for in dorsal and plantar flexors of the feet, flexors and extensors of the legs, and adductors of the thighs. Thus, there were 158 prime movers of these functions. Spasticity was found in 62 dorsal flexors of the feet, 67 plantar flexors of the feet, 67 flexors of the leg, 66 extensors of the leg, and 60 adductors of the thigh. In this group, spasticity seemed to be about equally distributed between flexors and extensors.

In severe injuries of the spinal cord in man the "pluck" reflex affords an opportunity for studying certain postural phases produced by rapid stretch of a muscle. The "pluck" reflex, described by Asayama,[6] was evoked by a brief tug at the tendon

1. Sherrington, C. S.: Decerebrate Rigidity and Reflex Coordination of Movements, J. Physiol. **22**:319 (pt. 4), 1898.

2. Liddell, E. G. T., and Sherrington, C. S.: Reflexes in Response to Stretch (Myotatic Reflexes), Proc. Roy. Soc., London, s.B **96**:212, 1924-1925.

3. Fulton, J. F.: Muscular Contraction and the Reflex Control of Movement, Baltimore, Williams & Wilkins Company, 1926, p. 103.

4. Denny-Brown, D. E., and Liddell, E. G. T.: Stretch Reflex and Spinal Process, J. Physiol. **63**:221, 1927.

5. Matthes, K., and Ruch, T. C.: Extensor Reflexes of Chronic Spinal Cat, Quart. J. Exper. Physiol. **22**:221, 1932.

6. Asayama, C.: The Proprioceptive Reflex of a Flexor Muscle, Quart. J. Exper. Physiol. **9**:265, 1916.

of a flexor muscle. This gave rise to a short-lived reflex response, and occasionally repeated ones, as in a clonus, each contraction being of short duration. In his study upon the decerebrate and the spinal cat the "pluck" never resulted in a prolonged contraction of the muscle.

In seeking for spasticity in our patients with lesions of the spinal cord we noted that, although relatively slow passive elongation of a muscle did not result in the characteristics of spasticity, often a sharp, sudden jerk of the muscle group resulted in a reflex contraction. The latency of this reflex seemed longer than that seen in elicitation of spasticity. The contraction which resulted consisted of two phases, the phasic one, consisting of a sudden, rapid contraction of the muscle with a marked deformation in its contour, producing a bulging, and a second phase, consisting of a slow relaxation after the contraction had lasted an appreciable time. This response differed from the characteristics of the pluck reflex as described by Asayama in that a second phase was present, and from a myotatic reflex, as seen in decerebrate preparations, in that it could be evoked only on sudden stretch. The reflex contraction evoked by the sudden stretch at times initiated another set of reflexes as ipsilateral flexion or extension.

Although it was not observed by Asayama, we consider the second phase of this reflex to be a postural component, which can be observed in injuries of the spinal cord in man. With this assumption, we felt we could compare the incidence of this modified "pluck" reflex with that of spasticity.

Of the total series of 950 muscle groups examined in 95 patients, 39% showed spasticity and 40% a modified pluck reflex; 48% of the muscle groups showed spasticity and 46.3% a modified pluck reflex when the cervical portion of the cord was injured; 51% showed spasticity and 61% a modified pluck reflex when the injury was between the 1st and the 9th thoracic segments, inclusive, and 20% showed spasticity and 20% a modified pluck reflex when the injury was between the 10th and the 12th thoracic segment, inclusive.

These total figures, however, do not reflect the true picture, which can better be studied by comparing the instances in which only spasticity was found, those in which only a modified pluck reflex was found, and those in which both were found. When this is done, it is noted that in many cases in which spasticity was found no modified pluck reflex could be elicited, and vice versa.

A small group of 18 cases were most carefully studied for the presence of this modified pluck reflex. In addition to the muscle groups already noted, there were added invertors and evertors of the foot, flexors and extensors of the thigh, abductors of the thigh, and internal and external rotators of the thigh. This made available 432 muscle groups. Of all the muscle groups studied, the percentage of muscles with spasticity was 37, and the percentage of muscles in which a modified pluck reflex could be evoked was 33. Spasticity alone was found in 78 muscle groups; a modified pluck reflex alone, in 55 muscle groups, and both, in 45 muscle groups.

There is, therefore, no correlation between the incidence of spasticity and the modified pluck reflex exhibiting a postural phase.

The order of frequency of the modified pluck reflex in the various muscle groups was as follows: flexors of the leg, 22 cases; adductors of the thigh, 21 cases; internal rotators of the thigh, 11 cases; extensors of the thigh, 10 cases; extensors of the

leg, 9 cases; plantar flexors of the foot, 5 cases; flexors of the thigh, 5 cases; dorsal flexors of the foot, 4 cases; external rotators of the thigh, 4 cases; evertors of the foot, 4 cases, and invertors of the foot, 3 cases.

One of the characteristics included in the description of spasticity is the concomitance of an increase of deep reflexes, at times even to the degree of eliciting clonus. Both the increase in the deep reflexes and the clonus are attributed to uninhibited stretch reflexes. The insistence, particularly by clinicians, that muscle stretch is the only adequate stimulus for all tendon and periosteal reflexes has led to such far-flung attempts to explain responses to stimuli quite at a distance, and even contralateral ones, that it has become almost absurd. The denial of the possible participation of other, perhaps nociceptive, stimuli has attained the fervor of a religion.

In our study of the reflex activities of an injured or severed spinal cord, analysis of the relation of the presence or absence of spasticity to increased deep reflexes revealed some interesting observations. When spasticity was present, the deep reflexes were practically always increased. However, in a series of 153 cases, no spasticity occurred in 68, in 29 of which the deep reflexes were present or increased. In a comparison of spasticity in the gastrocnemius muscle with the Achilles jerk when spasticity was present the deep reflexes were present or increased in 88%; when no spasticity was present they were present or increased in 60%. In a comparison of spasticity in the quadriceps muscle with the knee jerk when spasticity was demonstrated the deep reflexes were present or increased in 85%, and when no spasticity was demonstrated it was present in 93%.

The condition necessary for the production of spasticity also results in an increase of deep reflexes. In this case the conditions necessary only for the increase of deep reflexes are included with those necessary for the production of spasticity. However, the conditions necessary for the production of an increase of deep reflexes alone may occur independently of those necessary for the production of spasticity. However, the conditions necessary for the production of an increase of deep reflexes alone may occur independently of those necessary for the production of spasticity, and the deep reflexes may be increased when spasticity is absent.

In the elicitation of a deep reflex, the stimulus consists of a blow struck by a device, such as a reflex hammer. To be most effective, the blow should be of rather short duration. Thus, when one is examining for a knee or ankle jerk, the blow virtually produces a short tug upon the tendon. In this respect the stimulus is similar to that used in elicitation of the "pluck" reflex.

An analysis of data on the modified pluck reflex as we have found it in injuries of the spinal cord and an increase of deep reflexes revealed a far better correlation than that of spasticity and increased deep reflexes. Thus, in a study of 20 patients, when both extremities were examined, the knee jerk was present or increased in 37 extremities. In 26 of these the pluck reflex was elicited, whereas at that time, in that particular group, spasticity was found in but 7 instances. In 25 extremities the knee jerk was increased; in 16 the pluck reflex was present, and spasticity was found but once. This suggests that such deep reflexes as are known as tendon jerks may be increased as the result of conditions which in themselves do not produce spasticity. It suggests further that such reflexes are similar to pluck reflexes.

In discussing the characteristics of spasticity, it has been stated that the increase of deep reflexes may at times proceed to the degree of eliciting clonus. In clinical examinations, clonus is most readily obtained in the gastrocnemic group at the ankle, in the quadriceps and vastus muscles at the knee, and in the flexors of the wrist. All these muscle groups are well designed for the stimulus of a quick tug upon their tendons. In the case of the ankle and wrist clonus, to be effective, the muscle groups must, by some means, such as position, be brought into a condition of sufficient relaxation so that a passive lengthening of the muscle may be effected by the sudden thrust of the examiner's hand, which thrust is then sustained. In the case of the knee clonus, the adequate stimulus is effected by a sudden downward jerk exerted through the patella. Since a certain degree of relaxation must first be brought about, it is common experience to find that in the cases of greatest spasticity a clonus cannot be obtained, whereas an increase of the tendon jerk may easily be demonstrated.

It was not surprising, therefore, that in a group of 20 patients, when both extremities were examined, we found spasticity in 25 gastrocnemius groups, and that there were only 12 instances of ankle clonus and 15 of increase in the Achilles jerk without ankle clonus. In all the muscle groups with clonus, spasticity was present.

It will be recalled that at times Asayama noted a succession of phasic contractions of short duration when he suddenly plucked a muscle. In our opinion, the clonus we have elicited is very similar to these successive contractions, and it is suggested that clonus represents a form of the pluck reflex.

In contrast to muscles which are spastic because of a cerebral lesion, in the case of injuries of the spinal cord the muscles are so exquisitely sensitive to such a large number of stimuli, including exteroceptive ones from areas not related to a local sign of a reflex, that it is impossible in man to study a reflex isolated from the numerous ones combining to produce the increase over normal tension of a passively stretched muscle.

The reflex activities resulting from stretching a muscle may generally be termed stretch reflexes, but it should be kept in mind that of these there are a number which have been described, and probably others which have, as yet, not been discovered.

A number of types of receptors have been described by Matthews [7] in mammalian muscle, tendon, and fascial sheath. Their stimulation results in different rates of discharge and rapidity of accommodation. Since Adrian [8] pointed out that differences in adaptation rate correspond with the different types of reflex action which they produce, it is not strange that from stretching a muscle there may be produced a tonic spinal reflex resulting in a continuous slight tension of that muscle, and, in spinal cord injury, in the increase of such tension as may be seen in hemiplegia due to cerebral lesions, in the myotatic reflexes, as seen in the decerebrate, and at times in the spinal, preparation, in the pluck reflex, etc.

It is suggested that increased resistance to passive stretching of a muscle which is seen with injuries of the spinal cord and designated as spasticity may be the resultant of all, or a number of, these stretch reflexes, of exteroceptive ones, and of body reflexes, acting on the body.

7. Matthews, B. H. C.: Nerve Endings in Mammalian Muscle, J. Physiol. **78**:1, 1933.

8. Adrian, E. D.: The Mechanism of Nervous Action: Electrical Studies of the Neurone, Philadelphia, University of Pennsylvania Press, 1932.

CONVENTIONAL REFLEXES

Anatomically Complete Lesions

For the reason that at times responses of one side differed from those on the other, an analysis was made of both extremities in 22 cases of verified section of the spinal cord, excluding lesions of the lumbar segment. The Achilles jerk was found to be present in 15, increased in 12, and absent in 3, and the ankle clonus was found in 14. The knee jerk was present in 9, increased in 19, and absent in 10, and the knee clonus was found in 6. There was no correlation with the level of the lesion in this group.

The abdominal reflexes were generally absent until, in descending order, the ninth thoracic segment was reached, when the upper abdominal reflexes were present and the lower ones were absent. However, with lesions at upper levels, from one of the quadrants an abdominal reflex could be elicited in two cases, and in one case, with a defect of 6 cm. at the sixth thoracic level, all the reflexes were elicited.

The cremasteric reflexes were absent when the lesion was below the sixth thoracic level and were present in 3 of 12 cases when the lesion was above this level.

The plantar reflexes were of normal type in 10 extremities and absent in 12, and a Babinski sign was elicited in 2. There was no correlation with the level of the lesion.

The bulbocavernosus reflex was present in 18 of 22 cases and was absent in 1 of 2 cases with lesions at the 10th thoracic segment, in both cases with lesions at the 11th thoracic segment, and in 1 case with a lesion at the 12th thoracic segment.

The Deep Reflexes

Level of the Lesion.—In a series of 176 cases, of 23 cases of injury to the cervical segments, the deep reflexes were increased in 82% and absent in 18%. Of 80 cases of injury of the 1st to the 9th thoracic segments, inclusive, the deep reflexes were increased in 85% and absent in 15%; of 32 cases of injury to the 10th to the 12th thoracic segments, inclusive, the deep reflexes were increased in 43% and absent in 57%. Of 41 cases of injury to the lumbar portion of the spinal cord, the deep reflexes were increased in 24% and absent in 76%. Down to the level of the ninth thoracic segment there was no correlation with the level of the lesion. Below this the presence of the deep reflexes diminished as the levels descended.

There was no significant correlation between physiologically complete and incomplete lesions until the lumbar segments were reached, when the deep reflexes were absent with 88% of the complete lesions and with 68% of the incomplete lesions.

Plantar Reflexes

Difficulty is encountered in evaluating the response to plantar stimulation. Although the character of the response, plantar flexion, may be observed when the sole is stimulated, since the local sign of the reflex is lost and the same plantar response is observed from stimulation of the leg and thigh, plantar flexion is, after all, only a part of the general reflex pattern resulting from stimulation of any area below the level of the lesion. The significance, therefore, of plantar flexion of the toes is not the same as that of the reflex seen in normal man.

The same difficulty is encountered in studying the Babinski reflex. Having lost its local sign, it may be evoked from stimulation of any part of the lower extremities

below the level of the lesion. However, the most effective reflexogenous zones, in descending order, are the sole, the outer leg, the inner leg, the anterior thigh, and the inner thigh; surprisingly, the least effective zone was found to be the outer malleolus. On the other hand, with incomplete lesions, although the sole remained the most effective reflexogenous zone, the external malleolus shared with the inner aspect of the leg the third position of effectiveness. In cases in which section of the spinal cord was verified, the Babinski sign occurred consistently with flexor responses resulting from stimulation of the sole, but in other cases, in which an extensor response was elicited by stimulation elsewhere, it occurred as well, but in a smaller number of cases. The most effective stimulus of the sole was scratching. There was no correlation with the level of the lesion or with the completeness of the injury.

EXTEROCEPTIVE AND OTHER REFLEXES

Patterns of Ipsilateral and Contralateral Responses

By means of various stimuli applied to the skin of different portions of the lower extremities, various reflex patterns can be evoked. These are not as simple as pure flexor withdrawal or extensor responses. At the present time, many months to two or three years after injury, the reflex patterns have become very complicated. Whereas at first, perhaps, simple flexor or extensor movements made up the majority of responses, now, a number of years after injury, many patterns occur. They include flexor withdrawal; extension, with either abduction or adduction of the thighs—or at one time, one, and at another time, from a different area or stimulus, the other—or flexion followed by extension; extension followed by flexion; flexion followed by extension, then flexion, and extension, then flexion, then extension. These various ipsilateral responses are often associated with crossed responses, and these, too, are highly complicated. There may occur ipsilateral flexion and contralateral extension; ipsilateral extension and contralateral flexion; ipsilateral flexion and contralateral flexion; ipsilateral extension and contralateral extension; ipsilateral flexion, then extension, and contralateral flexion, or the reverse. Rarely, stepping and other alternate rhythmic contractions may be seen. In some cases more than one pattern may be evoked either from stimulation of a different area or from a change in the character of the stimulus. Usually the contralateral response follows the ipsilateral one by an appreciable, though short, period. Rarely, simultaneous responses occurred for the most part among the cases of verified sections of the spinal cord.

Of 18 cases of verified section of the spinal cord, the ipsilateral response was that of flexor withdrawal alone in 13, and either extension or flexion in 3, in two of which, in addition, there occurred at times extension, followed by flexion, and in the third, flexion was followed by extension, and this was repeated three times in succession. In 10 of these 18 cases, the ipsilateral reflex was associated with a contralateral one.

Of 26 cases of physiologically complete lesions due to gunshot wounds, an ipsilateral extensor response was found in 1; an ipsilateral flexion, in 13; either flexion or extension, in 5; flexion followed by extension, in 3, and extension followed by flexion, in 2. In three only fragments of a total reflex pattern occurred. In addition, in 12 a contralateral reflex occurred.

Of 22 cases of physiologically complete lesions due to fracture dislocations, the response was flexor in 12, extensor in 2, one or the other in 5, and extension, then flexion, then extension in 1. In eight a contralateral response occurred.

Of 17 cases of incomplete lesions, the response was flexion in 10, extension in 1, either flexion or extension in 2, and flexion followed by extension in 1. In four, only fragments of the patterns occurred, and these were with lesions of the lumbar region. In eight a contralateral reflex was found. There were few initial responses of an extensor type.

There was no correlation between type of injury, or level of the lesion, and the ipsilateral response.

The most frequent contralateral reflex in the 38 cases in which such a response occurred was ipsilateral flexion and contralateral flexion, of which 19 examples were seen; then ipsilateral flexion and contralateral extension, of which 8 instances were found; then ipsilateral extension and contralateral extension, of which 4 instances were found; then a scattering of the others. However, there was no correlation with the level of the lesion, except in the lumbar portion of the cord, where they were rare and the ipsilateral response consisted of but a fragment of one or two muscles, at times only a Babinski sign. However, in the anatomically complete lesions no contralateral response was observed when the lesion was below the eighth thoracic segment. Of 83 cases analyzed, contralateral responses were found in 38; they were present in a slightly greater percentage in incomplete lesions, but were few (17).

Efficacy of Stimuli and Responsiveness of Reflexogenous Zones

In a study of the order of efficacy of stimuli and responsiveness of reflexogenous zones, 194 patients with severe injuries of the spinal cord were examined. Plantar and dorsal flexors of the toes and feet; invertors and evertors of the feet; flexors and extensors of the legs and thighs; abductors, adductors, and internal and external rotators of the thighs were the muscle groups observed in relation to participation in reflexes evoked by stimulation.

Five stimuli were applied to seven areas and the results analyzed. The stimuli consisted of pinprick, scratch, brush, deep pressure, and repetitive pinprick. The areas stimulated were the sole, external malleolus, the outer surface of the leg, the inner surface of the leg, the outer aspect of the thigh, the inner aspect of the thigh, and the surface of the anterior thigh. The degree of efficacy of the stimulus was determined from a comparison of the numbers of reflex responses which occurred when one or another of the five stimuli was applied to each of the seven areas. The relative responsiveness of the seven areas was determined by comparing the numbers of reflex responses which resulted from application of each of the five stimuli to one or the other of the seven areas.

In addition, the total number of muscle group contractions participating in the various reflexes elicited by the five stimuli to each area was computed and compared with those for the other areas. Both sides were examined, because in many cases the responses were asymmetrical. This resulted in a potential of 13,580 responses. Were all the muscle groups to participate in each response, there would result a potential of 380,240 muscle group contractions. Of course, only a fraction of these could be expected. There resulted 4,455 reflexes out of a possible 13,580, and 13,376 individual muscle group contractions out of a possible 380,240.

For the sole, the order of efficacy of stimuli was scratch, deep pressure, repetitive pinprick, brush, and pinprick; for the external malleolus, scratch, deep pressure, repetitive pinprick, pinprick, and brush; for the outer surface of the leg, scratch, deep pressure, repetitive pinprick, pinprick, and brush; for the inner surface of the leg, scratch, repetitive pinprick, deep pressure, scratch, pinprick, and brush; for the inner aspect of the thigh, scratch, pinprick, repetitive pinprick, deep pressure, and brush, and for the anterior surface of the thigh, pinprick, scratch, deep pressure, repetitive pinprick, and brush.

The order of the responsiveness of the reflexogenous zones was the sole, outer surface of the leg, inner surface of the leg, inner aspect of the thigh, external malleolus, anterior surface of the thigh, and outer aspect of the thigh. The numbers of muscle group contractions from each area, in the same order, were 3,060, 2,765, 2,071, 2,063, 1,494, 1,294, and 1,494, respectively.

Development of Complicated Successive Reflexes

The synergistic action of muscle groups in the simple flexion or extension reflex is well known. Were it true that in the case of a completely severed spinal cord the induced reflexes were predominantly those of flexion withdrawal, one would expect to find that of the synergistic muscles, all would participate in approximately equal numbers. When late after injury a computation is made of all the muscle groups participating in the responses to a single stimulus, in a case of severed spinal cord the expected synergy of muscle groups of the flexor withdrawal reflex is not to be found. In fact, when a predominantly flexion reflex was induced, plantar flexion of the foot occurred many times as frequently as dorsal flexion, and in the predominantly extension type of reflex, a greater number was associated with dorsal flexion of the foot.

When the participation of all muscle groups in reflex activity induced by a single stimulus was computed in anatomically complete lesions, the order of frequency of muscle group participation from stimulation of the sole was the flexor of the thigh, the plantar flexors of the foot, and the flexors of the leg; the flexors of the toes; the adductors of the thigh; the evertors of the foot; the abductors of the thigh; the invertors of the foot and the internal rotators of the thigh; the dorsal flexors of the foot; the evertors of the foot; the quadriceps and external rotators of the thigh, and the extensors of the thigh. From other areas the order of frequency of muscle group responses differed. For example, from the anterior surface of the thigh, the order was flexors of the thigh; internal rotators of the thigh; plantar flexors of the foot; adductors of the thigh; flexors of the leg; plantar flexors of the toes; external rotators of the thigh; invertors of the foot; extensors of the thigh and leg; dorsal flexors of the toes; dorsal flexors of the foot; abductors of the thighs; external rotators of the thigh, and evertors of the foot.

The reason for this seemingly unrelated participation of muscle groups in reflex activity induced by a single stimulus may be found in the fact that the reflexes are no longer a simple flexion or extension, but involve a complicated series of successive reflexes, each group peculiar to the individual distal segment of the injured spinal cord being examined. This may be illustrated by a description of the march of events in successive reflexes evoked by a single stimulus.

March of Events in Successive Reflexes

In one case, after stimulation of the sole, there occurred a flexion of the toes and foot, followed after a short, but appreciable, length of time by flexion of the thigh; then shortly after by a contraction of the quadriceps and abduction of the thigh, and then by contraction of the abdominal muscles. In another case, there ensued a plantar flexion of the foot and toes, eversion of the foot, and flexion of the leg; then, later, contraction of the quadriceps; then, still later, flexion of the thighs. In still another case, dorsal flexion and inversion of the foot was followed by ankle clonus, then inversion of the thigh, contraction of the quadriceps, and adduction of the thigh. Again, a plantar flexion of the toes and foot, and flexion and abduction of the thigh were induced; then, later, contraction of the quadriceps and adduction of the thigh were followed by dorsal flexion of the toes and foot, inversion of the foot, and then flexion, internal rotation, and further adduction of the thigh. In another case, flexion and abduction of the thigh and contraction of the quadriceps were followed by adduction of the thigh and flexion of the leg. In still another case, plantar flexion of the toes and foot was succeeded by dorsal flexion of the toes and foot. As a last example, dorsal flexion of the toes and foot and eversion of the foot preceded by some time the plantar flexion of the foot and flexion and adduction of the thigh.

When crossed reflexes are elicited, they may occur at various times in the train of events of successive reflexes. This may be illustrated by the following example: Upon stimulation of the sole, there occurred dorsal flexion of the toes and foot, followed after an appreciable time by flexion and abduction of the thigh, with clonic twitches in the muscle groups involved in the movement, and then by a contraction of the quadriceps and an extension of the thigh and leg. This was simultaneous with a clonic contraction of the contralateral quadriceps and the adductors and extensors of the thigh.

It is obvious that there are many different integrated reflex activities in the spinal cord, which may be unmasked when inhibitory and other influences are interrupted at higher levels. We can only report, but cannot explain, them. However, it is obvious that with the passing of time after injury the explosive response of few reflex integrations disappears and many more patterns, peculiar to the individual injured spinal cord, are found.

Total Activity of the Distal Segment

When one records all the muscle group responses which follow the stimulation of seven areas by five stimuli, as before described, an index of the potential total activity of the distal segment of the spinal cord may be obtained by dividing the figure for the total number of muscle group contractions by the number of cases at each level. Such activity was studied in 32 cervical lesions, 74 lesions of the 1st to the 8th thoracic segment, 54 lesions of the 9th to the 12th thoracic segment, and 34 lesions of the lumbar region. The level of the lesion is definitely related to this total activity. For cervical lesions an average index of 30.5 was found; for lesions of the 1st to the 8th thoracic segment, inclusive, 30.1; for lesions of the 9th to the 12th thoracic segment, inclusive, 22, and for the lumbar lesions, 10.6. As the levels descended from the ninth thoracic segment, the responses became fewer and at times consisted only of the Babinski sign. For example, one may find only abduction of

the thigh, or adduction, internal rotation of the thigh, and a Babinski sign; or a Babinski sign and inversion of the foot; or plantar flexion of the toes and contraction of the quadriceps; or contraction only of the quadriceps; or plantar flexion of the foot and a Babinski sign, or dorsal flexion of the toes and plantar flexion of the foot. In lesions below the ninth thoracic segment, responses from the thigh became fewer as the level descended.

Thus, the greater number of segments in the distal portion of the injured spinal cord, the greater is the total activity of this portion of the cord; the smaller the number, and, thereby the fewer the facilitory impulses to the anterior horn cells, the less is the activity of these cells.

In general, there was no correlation with severity of the lesion, but at the level of the 9th to the 12th thoracic segment, inclusive, the average index for the complete lesions due to gunshot wounds was 100, and that for the incomplete lesions, 44; the average for complete lesions due to fracture dislocations was 76, and that for the incomplete lesions, 41. At the levels of the 1st to the 8th thoracic segment inclusive, no significant difference was found.

Crossed Gluteal Reflex

In a few cases, one of our residents, Dr. Harold J. Lawn, found a hitherto undescribed crossed gluteal reflex. The most effective reflexogenous zone was the opposite gluteal fold, and the most effective stimulus, cold. In this regard, this reflex resembled a crossed flexor response of the upper extremity when the opposite abdominal wall was stimulated by cold, formerly described by one of us (L. J. P.).

Lesions of the Cervical Portion of the Cord

In lesions of the cervical portion of the spinal cord, a few reflex responses were observed other than the conventional ones. With regard to so-called periosteal reflexes, striking the sternal end of the clavicle evoked contraction of the biceps in 2 of 21 cases, of the pronators of the forearm in 1 case, of the supinators in 1 case, of the deltoid in 1 case, of the trapezius in 1 case, and of the contralateral pectorals, supinators, and deltoid in 1 case. Striking the head of the radius evoked contraction of the deltoid in 1 case, of the internal rotators of the arm in 1 case, and of the flexors of the wrist in 1 case. Striking the styloid process of the ulna evoked contraction of the deltoid in 1 case, of the palmaris longus in 1 case, of the extensors of the fingers in 1 case, and of the extensors of the forearm in 1 case. Striking the insertion of the triceps evoked contraction of the biceps in 2 cases, and flexion at the metacarpophalangeal joints in another. Striking the dorsum of the hand evoked extension of the fingers.

Although many ingenious explanations may be found in the literature to show that all these responses are the result of stretch reflexes, many responses, we believe, are the result of nociceptive stimuli. Furthermore, they seem to be fragments of integrated reflex activities, the functional significance of which is not known. Many do not differ from those elicited in the lower extremities when lower levels are injured except that the effective stimulus is a sharp blow, rather than a stimulus applied to the skin.

In a few cases reflex responses result from stimulation of the skin of the upper extremities. Thus, in one case, stroking the palm resulted in dorsiflexion of the

wrist, adduction of the thumb, and ulnar deviation of the hand; in another case, cold applied to the medial surface of the arm produced twitching and adduction of the thumb; in another, stroking the skin over the hypothenar muscles resulted in extension of the wrist; in another, scratching the palm resulted in adduction of the thumb, extension of the index finger, and contraction of the opposite brachioradialis.

Yawning, in one case, was associated with adduction of the arms and flexion of the forearms; in another, with flexion of the forearms and wrist, and in another, with flexion of the arms and extension of the forearms. In one case, taking a deep breath was associated with flexion of the fingers at the metacarpophalangeal joints. Sneezing has also been accompanied by reflex movements.

Stimuli applied to levels below that of injury likewise resulted in reflex movements of the upper extremities. Thus, pricking the leg resulted in flexion at the metacarpophalangeal joints of the index, middle, and ring fingers; again, from pricking the medial surface of the leg there was observed extension of the middle and index fingers; in another case pricking the leg resulted in flexion of the index and middle fingers. In another case striking the sole evoked extension of the fingers.

A crossed flexor-pronator reflex of the upper extremity was found with injuries of the cervical region of the cord producing Brown-Séquard paralysis; when the analgesic abdominal wall was stimulated with cold, and only cold, pronation and flexion of the forearm of the opposite upper extremity occurred. This reflex has been described by one of us (L. J. P.).[9]

PSEUDOSPONTANEOUS SPASMS

The involuntary movements of the extremities seemingly unprovoked by stimuli have been termed spasms, in contrast to the reflexes induced by known stimulation. Since these pseudospontaneous spasms in some cases occur at irregular intervals, often but a few times a day, it was necessary to obtain some of the data by questioning those patients whose intelligence and sincere efforts in cooperation made their histories more reliable. Fortunately, the pattern of the pseudospontaneous spasm, with a large proportion of simultaneous movements of both lower extremities, makes it easier to distinguish this type from other induced reflexes.

Of 229 cases analyzed, pseudospontaneous spasms occurred in 73%—in 69% of cases of gunshot wounds and in 79% of cases of injuries due to fracture dislocations. Later, in an analysis of 80 cases in which a higher proportion of cases of peacetime fracture dislocations were included, pseudospontaneous spasms were found in 71%—in 79% of gunshot wounds and in 84% of fracture dislocations. The frequency of pseudospontaneous spasms was definitely related to the level of the lesion; they were found with 96% of cervical lesions, with 95% of lesions of the 1st to the 8th thoracic segment, inclusive, in 55% of lesions of the 9th to the 12th thoracic segment, inclusive, and in 40% of the 1st lumbar segment and below. Until the ninth thoracic level was reached, there was little difference in incidence of the spasms with anatomically complete, physiologically complete, and physiologically incomplete lesions. With lesions of the 9th to the 12th thoracic segment, inclusive, there were a greater number of pseudospontaneous spasms with the physiologically complete

9. Pollock, L. J.: A Crossed Flexion Reflex of the Upper Extremity: So-Called Abnormal Abdominal Reflexes, Arch. Neurol & Psychiat. **24**:358 (Aug.) 1930.

than with the physiologically incomplete lesions. In general, the severity of the lesion did not hold any relation to the frequency of pseudospontaneous spasms.

Pseudospontaneous spasms were noted for the first time as early as the fifth day after injury and, as an extreme, as late as 390 days after injury. Of the cervical injuries, they were noted 30 days or less after injury with 34% and later than 180 days after injury with 20%. Of lesions of the first to the eighth thoracic segment, inclusive, they were noted 30 days or less after injury in 40% and 180 days or more after injury in 20%. Of lesions of the 9th to the 12th thoracic segment, inclusive, they were noted 30 days or less after injury in 50% and 180 days or more after injury in 26%. Of the lumbar injuries, they were noted 30 days or less after injury in only 27% and 180 days or more after injury in 50%. With lumbar injuries, a significantly greater number of spasms occurred 180 days or more after injury. Once having occurred, they increased in severity in most cases. The period in which they reached their peak was variable—at times as short as three weeks; others continued to increase in severity for more than two years. Having reached a peak, many then diminished.

The anatomically complete lesions showed the fewest decreases in severity of pseudospontaneous spasms. They diminished in about 35% of all cases. About two years later, in an analysis of 88 cases, this percentage was raised to 77.2, the lesions in a great number of these cases of lessened severity being of the cervical portion of the cord. There was a correlation between the level of the lesion and the number of cases with lessened degrees of pseudospontaneous spasm. They decreased in 37% of the cases of cervical injuries, in 19% of the cases of lesions of the first to the eighth thoracic segments, inclusive, and in 12.5% of the cases of lumbar lesions.

At the same time, when flexor pseudospontaneous spasms diminished, extensor ones often began, at first in mild form and then increasing toward a peak, which in some of our cases has not as yet been reached. The decrease in severity of pseudospontaneous spasms did not seem to be related to recovery. Of 14 cases with unmistakable signs of recovery, there was a decrease in pseudospontaneous spasms in only 5. Rarely did the pseudospontaneous spasms disappear spontaneously—in only 6 of 152 cases investigated especially for this point. They were reported temporarily to be increased during inclement weather; pain and fever had little effect; exercise led to a diminution of spasms in 34 cases and an increase in 44 cases. They were precipitated frequently by handling of the genitalia; less frequently by catheterization, movement of an indwelling catheter, or by enema; in fewer instances by change of posture, standing in braces for a long time, or remaining in one position for a long time. In very few cases were they diminished by hot baths. In some cases they were said to be decreased by the use of alcoholic beverages.

These pseudospontaneous spasms presented many patterns. These included bilateral flexion and adduction or abduction of the thighs; abduction followed by adduction of the thighs; bilateral extension alone, or combined with adduction or abduction of the thighs; abduction followed by adduction; bilateral flexion followed by bilateral extension; bilateral extension, followed by bilateral flexion or, very rarely, by unilateral flexion and contralateral extension or unilateral extension and contralateral flexion. In some cases, more than one pattern existed; at times one, and at others another, being manifested, e. g., bilateral flexion at one time and bilateral extension at another, or bilateral flexion or extension at one time and

contralateral flexion and contralateral extension at another. In a few cases, three different patterns were observed.

As time elapsed after injury, changes occurred in the pattern of pseudospontaneous spasms. This may be illustrated by several cases.

In a case in which pronounced flexor withdrawal and posture had been present, about six months after the peak had been reached, the lower extremities, if they were carefully extended, would remain in that position for a time, the period increasing in duration as subsequent examinations were made, so that they remained extended as long as two hours. Then it was noted that extensor pseudospontaneous spasms began, which increased as the flexor ones diminished, especially when the legs were passively extended to about 130 degrees. In another case, flexor-adductor pseudospontaneous spasms were present for about a year; then extensor ones began and increased progressively. When the patient lay on his back, extensor types occurred; when he lay on his side, flexor spasms appeared. In another case, four to six weeks after injury, pseudospontaneous spasms, consisting of dorsiflexion of the right great toe, began and spread to the other side, and within two months the patient had severe flexor-adductor pseudospontaneous spasms, which were almost continuous. When they had reached their peak, extensor components began intermittently as flexor spasms became less severe. The latter reached their peak after two months and thereafter diminished.

In another case, flexor-adductor pseudospontaneous spasms occurred after two or three weeks and reached their maximum at almost the same time. They were so severe that it was necessary to tie the patient's extremities to a frame. Seven months after injury the intensity of the spasms abated, and restraints were unnecessary. At this time an extensor type of pseudospontaneous spasm developed and increased continuously in severity.

Pseudospontaneous spasms occur in the muscles of the upper, as well as of the lower, extremities. Of 21 cases of lesions of the cervical portion of the cord studied at one time, spasms were noted in 9. At times the spasms of upper extremities were associated with spasms of the lower extremities, but more frequently they occurred in the upper ones alone. In two cases they consisted of flexion of the forearm; in three, of flexion of the fingers; in one, of flexion of the wrist and fingers; in one, of flexion of the forearms and adduction of the thumb; in one, of flexion of the forearm and wrist, and in one, of extension of the fingers and thumb. Only three instances of crossed alternate movements were found among the cases of pseudospontaneous spasm.

Characterizing the pattern of these pseudospontaneous spasms was the preponderance of bilateral simultaneous similar movements, either flexion or extension, differing from the movements induced by stimuli applied to or through the skin, where such bilateral simultaneous similar movements were rare.

Another difference between the pseudospontaneous spasms and induced movements was that when all extensor and all flexor movements ipsilateral or contralateral were added, the number of extensor movements in the pseudospontaneous spasms was twice that of the induced reflexes, although the number of flexor movements was greater than that of the extensors in both types. Still another difference was found in that adduction of the thighs accompanied the pseudospontaneous spasms in a proportion of almost 3:1 as compared with abduction, whereas in the induced reflexes abductor and adductor movements were about equal in number. Neither the level of the lesion nor the degree of injury seemed to be related to the type of pattern.

The position of the patient in some cases was related to the pattern. Thus, while he was in the recumbent position, flexion and adduction might occur; when

he was sitting in a chair, extension and abduction would result, or the opposite condition might be noted.

We defined mass reflexes as consisting of a reflex motor response, along with emptying of the bladder and excessive sweating below the level of the lesion, the reflex being initiated by a full bladder. Defined as such, mass reflexes were relatively rare. They were found in 3 of 16 cases in which the spinal cord had been severed. in 8 of 43 cases of physiologically complete injuries due to gunshot wounds, in 3 of 30 physiologically complete injuries due to fracture dislocation, in none of 34 physiologically incomplete injuries due to fracture dislocation, and in 3 of physiologically incomplete injuries due to gunshot wounds, or a total of 17 cases among 151 cases.

However, a full bladder was an adequate stimulus for pseudospontaneous spasms in 42% of cases of cervical lesions, in 60% of cases of lesions of the 1st to the 8th thoracic segment, inclusive, in 71% of cases of lesions of the 9th to the 12th thoracic segment, inclusive, and in 75% of cases of lumbar lesions.

Pseudospontaneous spasm was said to evoke emptying of the bladder when a full bladder was not the effective stimulus in 44% of the cervical lesions, in 53% of lesions of the 1st to the 8th thoracic segment, inclusive, in 54% of lesions of the 9th to the 12th thoracic segment, inclusive, and in 25% of lumbar lesions. However, if the pseudospontaneous spasm occurred after urination had begun, it caused the flow of urine to stop in 28% of 151 cases.

When, in the series of 151 cases, pseudospontaneous spasms occurred, excessive sweating below the level of the lesion also occurred in 37 instances. A greater correlation between excessive sweating and pseudospontaneous reflexes was found with the complete lesions produced by gunshot wounds, both anatomically and physiologically complete.

There were a number of patterns of so-called coitus reflex, and in some erection of the penis accompanied the pseudospontaneous reflex.

It is our belief that all so-called spasms are reflex in nature. They are brought about chiefly from enteroceptive stimuli, usually visceral—a distended bladder, fecal masses in the rectum, anal fissures, distention of the intestine by feces or gas, movement of catheters, tugging on the mesentery by change of position, at times, irritation from sacral decubitus ulcers, and other midline stimuli, such as handling the genitalia. In support of this belief, it was found that when reflexes could not be induced by stimuli applied to areas below the level of the lesion pseudospontaneous spasms did not occur.

Experiments consisting of comparing the effects upon pseudospontaneous spasms of anesthetizing the spinal cord at the distal end of the proximal segment and at the proximal end of the distal segment confirmed this belief. We had found that introduction of a spinal anesthetic above the level of a lesion when a complete spinal fluid block was present abolished the diffuse burning pain in the lower extremities. This indicated that the anesthetic acted not only on the roots but on the spinal cord itself. When the spinal anesthesia was induced by introducing the drug low in the lumbar sac and allowing it to ascend to the level of the complete spinal fluid block, all reflex activities were abolished, and neither pseudospontaneous nor other reflex responses were observed. On the other hand, when the anesthetic was introduced above the spinal fluid block, reflex activities persisted. This seems to be crucial

proof that the pseudospontaneous spasms are the result of reflexes resulting from stimuli entering the spinal cord below the level of the lesion.

LEVEL OF THE LESION

From our study, we find many correlations between the level of the lesion and the resulting reflex activity of the distal segment of an injured spinal cord. It is true that, given a single case, one may not be able to determine any correlation between the reflex activities and the level of the lesion. When, however, an analysis is made of a large number of cases, differences between the reflex activities present when the lesions are at different levels may become apparent and their recording later lead to some understanding of function.

We have observed that for a long time after injury, but before that time when there is a mutation from flexor to extensor patterns, the percentage of cases with spastic flexor patterns is found to be greatest for the injuries of the cervical portion of the spinal cord. The percentage of such postures diminishes with ascending levels, especially below the eighth thoracic segment. Spasticity, likewise, is found in the greatest percentage with lesions of the cervical region of the spinal cord, and as the level of the lesion becomes lower and lower the percentage becomes progressively less. This is true also of pluck reflexes. Pseudospontaneous spasms occur in a greater proportion of cases of injuries to the cervical portion of the spinal cord and the first to the eighth thoracic segment, inclusive, than of cases of injuries below this level. Although there is no correlation between the pattern of ipsilateral and that of contralateral responses of noxious stimuli, with lesions of the lower thoracic and lumbar portions of the spinal cord, contralateral responses are fewer and ipsilateral ones are increasingly fragmentary as the level descends.

We have used the total numbers of muscles participating in contractions which make up a reflex movement, resulting from an adequate stimulus, as an index of total activity of the distal portion of the injured spinal cord. From such computations it was found that the total activity was greatest with lesions of the cervical and upper thoracic portions of the spinal cord and rapidly became less with lesions below these levels. As the level of the lesion descended, distention of the bladder as an adequate stimulus for pseudospontaneous spasms occurred in an increasingly greater proportion of cases, being least with lesions of the cervical portion and greatest with those of the lumbar portion.

When, quite late, flexor postures and pseudospontaneous spasms are superseded by extensor ones, it is notable that the posture of spastic extension occurs in a greater proportion of cases of injury to lower than to upper thoracic segments, and in a greater percentage of the latter than of injuries to the cervical portion of the cord.

It has been shown that position of the body may condition the pattern of pseudospontaneous spasms. Although neck reflexes in decerebrate rigidity have been widely studied, it has not been established that trunk reflexes, especially upper thoracic ones, do not participate, for example, in providing flexor attitudes. It is suggestive that such postures are present in greater proportions with cervical lesions of the cord. Since it has been proved that body reflexes act upon the body, it would follow that the longer the suprasegmental neural axis, the more reflex activity should be available. This, indeed, seems to be the case, since the reflex activity is

greatest with lesions of the cervical portion of the spinal cord and diminishes as the level of injury descends.

That the increased reflex activity is not the result alone of interruption of general inhibitory impulses may be seen from the fact that these activities differ when different levels of the spinal cord are injured, whereas if loss of inhibition were the sole cause the level of the lesion would be of no consequence. Furthermore, the pattern of reflex activity changes continuously.

DEGREE OF INJURY

The brilliant studies of Riddoch [10] on the reflex activities of the distal end of a severed spinal cord immediately or soon after the termination of the state of areflexia indicate that at that time very significant differences were found between those in cases in which the spinal cord was found to be severed and those with incomplete injury. Unfortunately, after the lapse of considerable time, in our material two or more years, these characteristic differences no longer can be discovered. It is impossible by a study of reflex activities to differentiate an anatomically complete from an incomplete lesion, or, in fact, a physiologically complete lesion from a physiologically incomplete one.

As time elapsed, the reflex of flexor withdrawal, associated with widespread discharge, combining with it emptying of the bladder and excessive pilomotor, sweating, and other responses, began to diminish in frequency and severity. At the same time, responses other than flexor withdrawal began to appear, whether the lesion was complete or not.

At the time our study was made, few differences between complete and incomplete lesions could be discovered. The few mass reflexes observed were found in greater proportion with complete lesions. The same was true of excessive sweating below the level of the lesion. When a complete lesion occurred below the eighth thoracic segment, we observed no contralateral reflexes. In these same levels the total activity of the spinal cord was greater with the complete lesion, whether gunshot wounds or fracture dislocations.

SUMMARY

Posture.—Paraplegia in flexion was not found to be related to the severity of the lesion but was definitely related to the level of the lesion. It was observed most frequently in lesions of the cervical portion of the spinal cord, next in lesions of the thoracic portion above the ninth thoracic segment, next in the remaining levels of the thoracic region, and least in lesions of the lumbar portion. As time after injury progressed, the posture changed from one in flexion to one in extension. At first, this became associated with lessening of spasticity of muscles, but later spasticity returned, especially with the lesions of the thoracic portion of the cord.

Stretch Reflexes: Spasticity, Myotatic, Pluck, and Deep Reflexes.—Spasticity in our studies was defined as a sustained increase over normal tension of a muscle when it is passively lengthened, this increase of tension being felt from the beginning of a passive movement. Furthermore, the tension increases in proportion to the extent to which the muscle is lengthened, and no local deformation of the muscle bundle

10. Riddoch, G.: The Reflex Functions of the Completely Divided Spinal Cord in Man, Compared with Those Associated with Less Severe Lesions, Brain **40**:264, 1917.

may be seen. Such spasticity may be observed in muscles spastic as a result of cerebral lesions, but it is not common to all cases of injury of the spinal cord, and often none is found. When present, it was not distributed predominantly in antigravity muscles but was found about equally distributed among flexors and extensors. In this respect it differed from the myotatic reflex.

The pluck reflex, described in flexor muscles by Asayama, was frequently seen in both flexors and extensors. Although he found only a phasic component in injuries of the spinal cord, we noted also a postural phase. The reflex seems to be related to certain tendon jerks and to clonus.

A number of different sense organs are stimulated by muscle stretch. Each has a different rate of adaptation, thereby explaining different types of response to muscle stretch. Included in these responses are the tonic spinal reflex, which in the normal muscle results in a sustained slight tension and, in the case of spinal cord injury, in uninhibited increase of this tension, myotatic reflexes, the pluck reflex, and probably other stretch reflexes. Furthermore, the exquisite sensitivity of the distal segment of the spinal cord to exteroceptive stimuli and body reflexes acting on the body produce muscle tensions inextricable from those produced by muscle stretch. The increase over normal of the resistance to passive lengthening of a muscle in spinal cord injuries is the resultant of many or all of these reflexes.

Conventional Reflexes.—Down to the level of the ninth thoracic segment, there was no correlation of the level to the presence, increase, or absence of the deep reflexes. Below this level they diminished in number as the level descended. Because of the loss of local sign, plantar flexion of the toes cannot be held to be a normal response, nor can the Babinski sign be believed to be similar to that found in cases of hemiplegia due to a cerebral lesion.

Exteroceptive and Other Reflexes.—The movements resulting from reflex contractions of muscles in response to exteroceptive stimuli change from simple flexion or extension as time elapses after injury to the spinal cord. Complicated diphasic and triphasic movements occur, both ipsilaterally and contralaterally. At times, stepping and other rhythmic movements are seen. Different patterns may result from stimulation of different areas or from use of different stimuli to one area. No longer can the reflexes be elicited from stimulation of the sole in cases of completely divided spinal cords; the response is always simple flexion. Contralateral responses are frequently found, which also produce complicated movements. The most frequent pattern was ipsilateral flexion and contralateral flexion, then ipsilateral flexion and contralateral extension, then ipsilateral extension and contralateral extension, and a scattering of other multiphasic responses. There was no correlation with the level of the lesion, except that when the lumbar area of the spinal cord was injured the contralateral responses were rare, and ipsilateral response consisted of but a fragment, often of one or two muscles, at times of only a Babinski sign.

The order of efficiency of stimuli when applied to the sole was scratch, deep pressure, repetitive pinprick, brushing, and pinprick. For other areas there was a different order of efficiency.

The order of the responsiveness of the reflexogenous zones was the sole, outer leg, inner leg, inner thigh, external malleolus, anterior thigh, and outer thigh.

Not only have the reflex movements changed from simple flexion, in that either flexion or extension, or extension or diphasic and multiphasic reflex movements

may ensue, but each response to a single stimulus is made up of a train of separated successive movements or muscle contractions. Many times the functional significance of the various combinations is not apparent. Thus, it becomes impossible to study synergistic muscles, as is readily done with simple flexion or extension reflexes.

By computing the total number of muscle groups which contract when reflexes are induced by application of five different stimuli to seven different areas, an index could be made of the total activity of the distal end of the injured spinal cord. This index of total activity was found to be greatest with lesions of the cervical region and the 1st to the 8th thoracic segment, inclusive, less in the 9th to the 12th thoracic segments, inclusive, and least in the lumbar segments. As the levels descended below the ninth thoracic segment, the muscle group responses became fewer, and in lower levels perhaps only a Babinski sign might result.

Reflex Activities in Injuries to the Cervical Portion of the Spinal Cord.—Reflex movements resulting from striking a blow over the periosteum in various locations and of nociceptive stimuli to the upper and lower extremities are described. The activities seem to be similar to the integrated movements in lesions at lower levels. A crossed flexor-pronator reflex of the upper extremity followed stimulation by cold of the analgesic abdominal wall in some Brown-Séquard lesions.

Pseudospontaneous Spasms.—The incidence of pseudospontaneous spasms was highest with lesions of the cervical region and diminished as lower levels were injured. The spasms occurred earlier with lower thoracic and cervical lesions, later with upper thoracic lesions, and often quite late in lumbar ones. They decreased less with the anatomically complete lesions. The lower the level of injury, the fewer the cases in which spasms decreased.

After the initial flexor-adduction withdrawal type, many other patterns developed later, the pattern in some cases depending on the posture of the patient. At the beginning, fragmentary responses develop into a primitive withdrawal response. Later, many activities, consisting of numerous patterns, develop. These independent formations, representing some unknown, but probably useful, integrations, suggest newly developed conditioned reflexes.

Mass reflexes were few, but a full bladder was the effective stimulus for pseudospontaneous reflex spasm in a large number of cases. The pseudospontaneous reflex evoked emptying of the bladder in a considerable number of cases, being fewest with lumbar lesions. However, these spasms also interrupted micturition if the pseudospontaneous spasm occurred after its start. The pseudospontaneous spasm evoked excessive sweating in about 25% of cases. That pseudospontaneous spasms differ from the reflexes induced by stimulation of or through the skin below the level of the lesion is seen from the fact that the former are almost always bilateral simultaneous similar responses, whereas the latter are ipsilateral, or less frequently contralateral, are not simultaneous, and are of alternating character. Furthermore, adduction of the thighs predominates among the pseudospasms, as do extensor responses.

We hold pseudospontaneous reflexes to be of reflex origin. This belief is supported by the fact that when reflexes cannot be evoked by exteroceptive or proprioceptive stimuli no pseudospontaneous spasms occur. Anesthetizing the proximal end of the distal segment does not abolish pseudospontaneous spasms, but anesthetizing the roots of the whole distal segment abolishes these spasms. This seems to

be a crucial experiment to show that these pseudospontaneous spasms result from reflexes in the distal portion of the cord and not from impulses originating in the proximal end of the distal segment.

Level of Lesion.—The greater the number of segments in the distal end of the injured spinal cord, the greater is the potential total activity. The smaller the number of segments, the fewer are the reflex responses and the more fragmentary are the muscle group contractions. Spasticity, pluck reflexes, and pseudospontaneous spasms are most frequently found with injury of the cervical and upper thoracic portions of the spinal cord. With the former there are fewer instances of change from flexor to extensor positions, which occur mostly in lower thoracic injuries. The efficacy of a distended bladder as stimulus for a pseudospontaneous spasm is less in the cervical and the upper thoracic segments than below.

Proof that responses to stimuli resulting in pseudospontaneous spasm or induced reflexes are not the result of general lessening of inhibitions is found in the differences in reflex activity with injuries at different levels in respect to frequency and completeness of response and, in addition, to the change in character of the response as time elapses after injury. This suggests that remaining suprasegmental levels in respect to the reflex again assume function and that the distal end of the injured spinal cord can, as though by conditioned reflexes, assume activities, the functional significance of which we cannot explain.

Degree of Injury.—Long after injury, the reflex activities of the distal segment of a severed or severely injured spinal cord have changed to such a degree that no longer is it possible by any reflex characteristics to differentiate complete and incomplete lesions.

Dr. Benjamin H. Kesert and Dr. Stanley W. Pyzik, and our residents Dr. John J. Antel, Sherman E. Kaplitz, Harold J. Lawn, Gerald S. Lietz, Frederick M. Peters, Bernard S. Schaeffer, Israel Zivin, Herman Blustein, John R. Mullins, and J. K. Smith assisted in the examination of the patients.

COURSE AND PROGNOSIS OF DISSEMINATED SCLEROSIS IN RELATION TO AGE OF ONSET

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LITTLE information regarding the importance of the age of onset to the course and prognosis of disseminated sclerosis is found in the literature. Any such information is usually expressed in general terms and is not substantiated by an account of series studied. Thus, statements regarding the course of the disease have been made by Laignel-Lavastine and Koressios,[1] Pette,[2] and Brain,[3] among others. They expressed the opinion that the disease often has a progressive course when the onset takes place at a more advanced age. Beringer[4] did not agree with this view.

The series reported are not sufficiently large to permit statistical analyses, and the data regarding their composition are often incomplete. McAlpine[5] made a follow-up study of 142 patients and found that the course of the disease was usually progressive when the patient was in a higher-age group at the onset. In an autopsy material, comprising 42 cases, published by Friedman and Davison,[6] the course was progressive in 6 of the 9 cases in which the illness began after the age of 40. There is good reason to assert that a disease with so variable a course as disseminated sclerosis is unsuitable for a classification based on this aspect. Nor do the authors attempt to differentiate the various forms, and such a method is scarcely feasible in practice.

The question of the prognostic importance of the age of onset is treated in a similar manner. Vierheilig[7] made a study of a series of patients, of whom no detailed description was given. On the basis of a follow-up examination, he tabulated the patients according to the age of onset, showing the number who had died, the number who had become disabled, and the number who were able to work at

From the Medical Department (Director, Prof. A. Kristenson), and the Neurological Department (Director, Prof. A. Antoni) of Serafimerlasarettet.

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5. McAlpine, D.: The Problem of Disseminated Sclerosis, Brain **69**:233-250, 1946.

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the time of the report. He made no statement regarding the length of the observation period for the respective patients. It may be inferred from the table that the prognosis with regard to the working ability is more favorable when the age of onset is low. There was no correlation of the mortality and the age of onset. The series, however, is too small to permit any definite conclusions. Thygesen [8] made a personal follow-up examination of 110 patients with disseminated sclerosis, the observation period varying from eight to 15 years. Judging from his results, the prognosis is not dependent on the age of onset. His series was not a representative sample of the disease but must, in many respects, be considered to present a bias. Henner, Pitha, and Vinař [9] made a study of the course of the disease but threw no light on the problems to be discussed in the present paper.

Gram [10] and Sällström [11] studied the relation of the age of onset to the duration of the disease. The series were large in both investigations, but the authors erroneously based their calculations only on the patients who were dead at the time of the follow-up examination. They did not take into account the duration of illness of the patients who were still alive. In both series, the duration of the disease for the deceased patients was somewhat longer when the onset had occurred at an early age than when it had occurred at an advanced age.

Briefly, it may be stated that no authoritative investigation of the importance of the age of onset for the course and the prognosis of the disease has been published. Definite knowledge of these matters is therefore lacking. The present paper is an extract from a monograph published in 1949,[12] to which have been added the results of more recent, unpublished investigations.

PRESENT INVESTIGATION

Patient Material.—The series was assembled in 1946 and was selected on the basis of the diagnosis of disseminated sclerosis and of treatment in various neurological departments in Sweden between 1920 and 1945, inclusive. Both inpatients and outpatients were represented. The number of clinically undoubted cases was 1,194. I had intended to visit all those patients who were still alive in 1946 and the relatives of those who had died, in order to make a complete neurological examination of those living and to obtain data regarding the course of the disease. The address of the patient or that of his relatives was available in 95% of the cases. For geographical reasons, 191 patients were excluded. An additional 28 did not undergo a follow-up examination, for various reasons. The final series thus consisted of 810 patients. Presumably, the patients excluded on geographical grounds would not have affected the composition of the series in any respect of essential importance to the present investigation, since the course of the disease can scarcely be assumed to vary in different parts of the country. Moreover, I was able to ascertain by correspondence that the development of the disease was not extreme in any of the aforementioned 28 patients.

Various investigations, of which an account is given in my publication of 1949, show that the series is a representative sample of the disease.

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10. Gram, H. C.: Den disseminerede sklerosens forekomst i Danmark, Ugesk. læger **96**:823-825, 1934.

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The follow-up examination included an interview not only with the patient but also, as a rule, with one or several of his relatives. An interview with the latter was always obtained when the patient had died prior to the examination. The majority of the patients had been treated more than once at the aforementioned neurological departments, in addition to spending one or several periods in other hospital departments or in homes for the chronically diseased. Information regarding the patients was obtained from all these sources. It was thus possible to reach fairly definite conclusions with regard to the course of the disease in the individual case.

The mean observation period, i. e., the time between the first period of treatment at the specified neurological department sometime between 1920 and 1945 (registration) and the follow-up examination, in 1946, was 9.7 years. In 71% of the cases the observation period was 5 years or more; in 46%, 10 years or more, and in 23%, 14 years or more. The mean duration of the disease before registration was 5.6 years. One-half the patients were registered during the year of onset of the disease or the two subsequent years. The observation period showed no correlation with the age of onset. The duration of the disease before registration, on the contrary, was found to decrease with advancing age at the onset.

Of the 810 patients, 357 were men and 453 women. The preponderance of women was due to the conditions of admission in one of the neurological departments in question. The age of onset, which was known for 793 patients, is shown in Table 1. Six per cent of the patients were under the age of 15 at the onset; 52%, under 25, and 8%, 40 or older. The mean age of onset was somewhat lower for the women than for the men.

TABLE 1.—*Distribution According to Age at Onset of the Disease and Sex*

Age at Onset, Yr.	Both Sexes	Men	Women
5- 9	3	0	3
10-14	43	11	32
15-19	129	49	80
20-24	236	104	132
25-29	130	67	63
30-34	117	50	67
35-39	72	35	37
40-44	46	22	24
45-49	11	4	7
50-54	5	3	2
55-59	1	0	1
Unknown	17	12	5
Total	810	357	453

Methods and Definitions.—The statistical methods used are discussed in my publication of 1949.[12] As I pointed out in the introduction to this paper, disseminated sclerosis is unsuitable for a classification on the basis of the course of the disease. I have therefore used, instead, various types of bouts as a working basis.

When new symptoms appear, symptoms earlier present recur, or existing symptoms become exacerbated, a new bout of the disease is said to occur. In the case of exacerbation of an existing symptom, this symptom must have been regressive or stationary for at least one month in order for an exacerbation to be interpreted as a new bout.

A new bout may consist of several symptoms, provided that they appear within a relatively short time—in the present study not in excess of one week.

The bouts are classified as remittent or progressive. The former consist of symptoms which have entirely or partly regressed or which have become stationary after progression for a short time. The latter comprise one or several symptoms which have from their onset become successively more pronounced. Thus, when bouts of the latter type occur, the disease enters a steadily progressive stage. Reference is made to my publication of 1949 for comments on these definitions.

In the present series, there were 3,797 bouts; 133 (4%) could not be assigned to one or another of the categories.

The material was, as a rule, divided into two groups, i. e., patients with age of onset below 25 and patients with onset at 25 or above. The first group comprised 411 patients (164 men); the latter, 382 patients (181 men). The latter group was divided into subgroups, i. e., age of onset 25 to 34 (247 patients; 117 men), and age of onset 35 or more (135 patients; 64 men).

Results.—It is seen from Table 2 that motor disturbances as the initial symptom were considerably commoner among the older patients. If the first bout was classified as progressive or remittent, it was found that pareses of the extremities were consistently commoner among the older patients. Cerebellar symptoms, in the form of intention tremor or dysmetria, were, on the contrary, more usual among

TABLE 2.—*Composition of First Bout and of Progressive and Remittent Bouts in General*

Age at Onset, Yr.	No. of Bouts	Symptom Groups: Cranial-Nerve Disturbances, %	Motor Disturbances, %	Sensory Disturbances, %	Sphincter Disorders, %	"Other Symptoms," %	Pareses of Extremities, %	Intention Tremor and/or Dysmetria, %
First Bout								
Less than 25.....	411	57	85	25	3	2	22	2
25 and over.....	382	40	59	31	7	2	46	4
Difference		17 ± 3.5	24 ± 3.4	6 ± 3.2	4 ± 1.6	0 ± 1.0	24 ± 3.3	2 ± 1.2
Progressive Bouts								
Less than 25.....	269	12	91	19	30	18	65	36
25 and over.....	430	7	92	22	29	13	80	18
Difference		5 ± 2.3	1 ± 2.2	3 ± 3.0	10 ± 3.7	5 ± 2.8	15 ± 3.5	18 ± 3.5
Remittent Bouts								
Less than 25.....	1,798	46	43	34	6	2	29	3
25 and over.....	1,102	42	40	33	12	3	29	2
Difference		4 ± 1.9	3 ± 1.9	1 ± 1.8	6 ± 1.1	1 ± 0.6	0 ± 1.7	1 ± 0.6

TABLE 3.—*Calculated Incidences of Occurrence of a New Bout Within a Fixed Time of Appearance of First, Second, Third, and Fourth Bouts*

Ordinal No. of Bout	Age Less Than 25: Calculations Based on No. of Patients Below	No. of Years After Appearance of Relevant Bout: 1	2	3	Age 25 and Over: Calculations Based on No. of Patients Below	No. of Years After Appearance of Relevant Bout: 1	2	3	χ^2 Test on Comparison of Age Groups Less than 25 and 25 and Over
		%	%	%		%	%	%	
1	411	45	61	72	382	54	75	84	$P < 0.3\%$
2	396	50	66	77	365	53	74	82	$P > 5.0\%$
3	347	54	73	78	308	42	57	66	$P < 0.3\%$
4	290	50	68	77	267	42	55	63	$P = 5\text{-}1\%$

the younger patients, but only when the bout was progressive. In the lower-age groups cranial-nerve disturbances were oftener found as an initial symptom than in the higher-age groups (Table 2).

Table 2 also permits a study of the composition of all the progressive and remittent bouts, with a classification of the material according to the age of onset (below 25 and at or above 25). The age of onset affected the progressive bouts chiefly with regard to the incidence of various kinds of motor disturbances. Considered as a whole, the incidence of these disturbances was the same in the two age groups, but pareses of the extremities were commoner at an advanced age and intention tremor and dysmetria at a lower age. If the progressive bouts are

classified on the basis of the interval between the onset of the respective bout and the onset of the disease—less than 3 years; 3 to 10 years, and 10 years or more—it is found, nevertheless, that a difference in the incidence of paresis is present only when the interval does not amount to 10 years. The difference in the incidence of intention tremor and dysmetria is found even with a longer interval. The composition of the remittent bouts did not vary appreciably with the age of onset.

Table 3 presents a calculation of probability. It shows how many of 100 patients who were below the age of 25 and how many who were 25 years or older, respectively, at the onset of the disease, would have a new bout within a certain

TABLE 4.—*Percentage of Patients Who Had Progressive Bouts During a Certain Time After Onset of Disease*

	Age Less Than 25		Age 25-34		Age 35 and Over		
No. of Years, *t*	Total No. of Patients with Observation Period of at Least *t* Yr.	No. of Patients with Progressive Bouts During First *t* Yr. After Onset, %	Total No. of Patients with Observation Period of at Least *t* Yr.	No. of Patients with Progressive Bouts During First *t* Yr. After Onset, %	Total No. of Patients with Observation Period of at Least *t* Yr.	No. of Patients with Progressive Bouts During First *t* Yr. After Onset, %	χ^2 Test on Comparison of Respective Age Groups
2	390	10	234	34	127	67	$P < 0.3\%$
5	286	17	181	49	98	81	$P < 0.3\%$
10	187	34	112	64	64	86	$P < 0.3\%$
15	95	52	58	67	32	91	$P < 0.3\%$

TABLE 5.—*Calculated Incidences of Occurrence of a New Bout When All Earlier Bouts Are Remittent and When One or More Are Progressive*

	(*a*) Remittent Bouts Only				(*b*) One or More Progressive Bouts				
Ordinal No. of Bout	Calculations Based on No. of Patients Below	No. of Years After Appearance of Relevant Bout			Calculations Based on No. of Patients Below	No. of Years After Appearance of Relevant Bout			χ^2 Test on Comparison of *a* and *b*
		1	3	5		1	3	5	
		%	%	%		%	%	%	
1	691	50	69	78	102	43	63	75	$P = 1\text{-}0.3\%$
2	572	56	74	83	189	37	59	67	$P < 0.3\%$
3	428	57	79	85	227	30	41	49	$P < 0.3\%$
4	316	55	73	82	181	28	40	48	$P < 0.3\%$
5	213	52	71	76	131	29	38	..	$P < 0.3\%$

time of the onset of the first, second, third, and fourth bouts, respectively. Thus, 84% of the higher-age group, but only 72% of the lower-age group, are calculated to have had a second bout within five years of the onset. The incidence of a third bout would also be higher in the higher-age group. The incidence of the fourth and fifth bouts, on the contrary, would be higher among the patients who became ill at an early age. The increase in the mortality rate with increase in age at the onset can contribute only to a slight extent to the last-mentioned fact.

The incidence of progressive bouts during the first *t* years of the disease was studied in that part of the material in which the observation period (for the definition, see the section on "Patient Material") amounted to at least *t* years (Müller [12]).

With an increase in the age at the onset, the progressive bouts occurred at successively shorter intervals (Table 4). The difference between the age groups is considerable and cannot be explained on the grounds of the variation in the symp-

toms at the onset. In 3% of the youngest patients (below 25) the initial bout was progressive. One of the first three bouts was progressive in 18% of the younger patients. The corresponding figures for the older patients were 24 and 56%.

As may be inferred from Table 5, the interval between the bouts was longer for patients with a progressive bout. There is reason, therefore, to assume that the difference between the age groups in Table 3 with respect to the frequency of a second and third bout would have been greater had the calculations been based only on patients with remittent bouts. It is also probable that the incidence of a fourth and fifth bout would have been higher for the older patients than for the younger, as was the case in the table. The size of the series did not, however, permit such a calculation for the frequency of the bouts.

TABLE 6.—*Calculated Incidences of Deaths Within a Certain Time of Onset of Disease*

Age at Onset, Yr.	Calculations Based on No. of Patients Below	No. of Years After Onset			
		2	5	10	15
		%	%	%	%
Less than 25	65	0	2	11	20
25 and over	62	5	10	21	31

TABLE 7.—*Percentage of Deaths During Different Periods of Observation*

Age at Registration, Yr.	No. of Deaths a Stated No. of Years After Registration, in % of No. of Patients with Observation Period of at Least Same No. of Years							
	2 Yr.		5 Yr.		10 Yr.		15 Yr.	
	No. of Patients	No. of Deaths, %	No. of Patients	No. of Deaths, %	No. of Patients	No. of Deaths, %	No. of Patients	No. of Deaths, %
Less than 30	334	4	257	9	165	19	85	29
30-39	281	4	204	12	135	21	63	40
40 and over	155	7	118	21	71	34	42	52
Difference		3 ± 2.3		12 ± 4.2		15 ± 6.4		23 ± 9.1

For reasons that will not be entered into here, a study of the mortality rate on the basis of the age at onset was made only on a part of the series, i. e., 127 patients (Müller [12]). The incidences given in Table 6 were found in a calculation of probability based on the actual incidences in this series. It is seen from the table that the mortality rate was higher when the age of onset was 25 or above than when the patients were younger. The series is not, however, sufficiently large to permit any definite conclusion.

The mortality rate was also studied on the basis of the registration (for the definition, see the section on "Patient Material"). The number of deaths with the various periods of observation is shown in Table 7. The mortality rate is seen to increase with an increase in the chronological age on registration. This tendency remains even if the incidences in Table 7 are reduced in view of the increase in the mortality rate in the general population with advancing age. Nor can the variations in the symptoms on registration explain the difference in the age groups.

The incidence of disablement (physical disablement only) was also dependent on the age of onset. This may be inferred from Table 8, which is set up on the same

principles as Table 4. The older patients became disabled more rapidly than the younger ones. This also applied when a comparison was made of patients with the same initial symptoms.

The transition from slight to complete disablement was rapid, irrespective of the age at onset. According to my calculations, one-half the patients may be expected to be completely invalided within five years.

Of the patients in the three age groups who were disabled two years after the onset of the disease (Table 8), 68, 81, and 92%, respectively, had progressive bouts.

TABLE 8.—*Percentage of Patients Invalided During a Certain Time After Onset of Disease*

	Age Less Than 25		Age 25-34		Age 35 and Over		
No. of Years, t	Total No. of Patients with Observation Period of at Least t Yr.	No. of Patients Invalided During First t Yr. After Onset, %	Total No. of Patients with Observation Period of at Least t Yr.	No. of Patients Invalided During First t Yr. After Onset, %	Total No. of Patients with Observation Period of at Least t Yr.	No. of Patients Invalided During First t Yr. After Onset, %	χ^2 Test on Comparison of Respective Age Groups
2	387	12	230	36	124	60	$P < 0.3\%$
5	283	23	178	56	95	83	$P < 0.3\%$
10	186	39	111	68	63	89	$P < 0.3\%$
15	94	55	58	71	31	90	$P < 0.3\%$

TABLE 9.—*Percentage of Invalids on Registration and Incidences of Invalidity After Registration*

Observation Period, Yr.	Period of Illness Prior to Registration, Yr.	Age on Registration, Yr.	Total No. of Patients	No. of Patients Invalided on Registration, %	No. of Noninvalids on Registration	No. of Noninvalids Invalided After Registration, %
1-10		Less than 30	136	4	130	32
	Less than 3	30 and over	82	23	63	76
	3 and over	Less than 30	59	31	41	39
		30 and over	198	47	104	42
11-26	Less than 3	Less than 30	97	7	90	50
		30 and over	62	16	52	73
	3 and over	Less than 30	53	19	43	64
		30 and over	166	43	60	72

χ^2 test on incidences of invalidity after registration on comparison of the various age groups

Duration of Disease, Yr.	χ^2 Test
Less than 3.....	$P < 0.3\%$
3 and over.....	$P > 5$ %

The difference between the percentage for the lowest-age group and that for the highest-age group is statistically significant ($24 \pm 7.7\%$). Thus, the disease in the younger patients was more frequently disabling before it entered a progressive stage. On the other hand, the patients rapidly became disabled, irrespective of the age of onset, once the disease had entered this stage. Within two years over 90% of patients with progressive disease were disabled.

The incidence of disablement after registration is shown in Table 9. The patients are classified according to the length of the observation period, the duration of the disease before registration, and the age on registration. With a short duration before registration, the incidence of invalidity after registration was considerably lower

among the younger patients. With a long duration, no essential difference was found between the age groups. This is because with the shorter duration before registration the age at onset of the disease differed in the two age groups. With the longer duration, on the contrary, approximately 40% of the patients became ill before the age of 25. The majority of the remaining patients were already invalids on registration and did not, therefore, affect the incidence of invalidity after registration. Thus, with a long duration of the disease before registration, the age at onset of the disease was approximately the same for the nondisabled patients in the two age groups. Irrespective of the duration before registration, a considerably larger number of invalids were found among the older patients on registration.

At the follow-up investigation, 620 patients were alive, and 337 were disabled (22 of the disabled did not undergo a complete examination). Among the invalids,

TABLE 10.—*Symptoms in the Invalids at the Follow-up Examination*

		No. of Invalids with Relevant Symptoms					
Age at Onset, Yr.	Total No. of Patients	Cranial-Nerve Disturbances, %	Motor Disturbances, %	Sensory Disturbances,* %	Sphincteric Disorders, %	"Other Symptoms," %	Mental Disorders, %
Less than 25	133	83	100	95(9)	80	41	47
25 and over	175	78	100	98(21)	82	37	57
Difference		5 ± 4.5			2 ± 4.5	4 ± 5.6	10 ± 5.7

* The figures in parentheses denote the number of patients for whom data are lacking with respect to the occurrence of the relevant symptoms. These patients are not included in the incidences given.

TABLE 11.—*Symptoms in the Noninvalids at the Follow-Up Examination*

		No. of Noninvalids with Relevant Symptoms*					
		I		II		III	
Age at Onset, Yr.	Total No. of Noninvalids	Absolute No.	%	Absolute No.	%	Absolute No.	%
Less than 25	178	69	39	33	19	76	43
25 and over	83	42	51	18	22	23	28
Difference			12 ± 6.6		3 ± 5.4		15 ± 6.2

* I indicates motor and/or sphincter disturbances; II, no symptoms or symptoms from only one symptom group, with no motor or sphincter disturbances, and III, symptoms from more than one symptom group, with no motor or sphincter disturbances. For the different symptom groups, see Table 10.

only small differences in the incidence of the various symptom groups were found with a difference in the age of onset (Table 10). Dysmetria and intention tremor were, however, considerably more frequent with a low age of onset, i. e., 64% with onset below 25 and 38% with onset at 35 or above (difference, 26 ± 7.1%). The incidence of paresis of the extremities did not, however, differ with the age of onset.

A complete examination was not made of 16 of the 283 noninvalided patients. Those patients who became ill at an early age showed a higher incidence of motor and/or sphincter disturbances, but the difference is not large and can be explained on the grounds of a random variation (Table 11).

On the whole, the symptoms were independent of the duration of the observation period, both for the disabled patients and for the nondisabled patients.

COMMENT

Approximately one-half the patients with disseminated sclerosis become ill before the age of 25, and less than 10% at the age of 40 or over. It is interesting to note that the course and prognosis of the disease are determined to a great extent by the age of the patient at the onset.

In older patients, the first bouts occur at shorter intervals than in younger patients. This is presumably true also with regard to subsequent bouts, as long as the disease has not entered a steadily progressive stage. This implies that with more advanced age at the onset, patches giving rise to clinical symptoms occur more frequently. This does not necessarily mean that the actual number of patches is greater, but may be explained by a greater susceptibility of the nerve paths, so that clinical symptoms more readily develop. It is also possible that the site of the patches may play a role, those in younger patients being oftener found in so-called silent zones. Support for the latter hypothesis is afforded by the fact that the nature of the symptoms is to some extent dependent on the age at onset.

In older patients, the disease frequently enters a steadily progressive stage as early as with the first three bouts; i. e., one or more of the bouts becomes progressive, whereas in younger patients this is uncommon. The difference is also evident with regard to the time for the onset of the first progressive bout. With more advanced age at the onset, it becomes increasingly common for the disease to enter a steadily progressive stage during the first years.

The progressive bout is characterized by the successive intensity of some or all of the symptoms. The anatomical basis may be a patch which gradually extends within a certain conducting system, resulting in increasing destruction of the nerve paths. It is also conceivable that the relatively even progression that can be noted clinically is caused by the successive occurrence of new patches in the conducting system involved. Slowly progressing spastic monoparesis may be due to a patch in the pyramidal tract which becomes increasingly extensive and causes successive destruction. It may, however, be caused by the successive appearance of fresh patches in this tract, all of which result in paresis of the related extremity. The fact that with a higher age at the onset the disease became steadily progressive after a shorter time could be explained on the basis of an increasing susceptibility of the conducting nerve paths.

Progression of the disease is characterized, practically without exception, by increased motor disturbances. Their nature is in some degree dependent on the age at onset of the disease. Spastic pareses of the extremities are common, irrespective of the age of onset, but are oftener found at an advanced age. Cerebellar disturbances, on the contrary, are more frequent at an early age of onset and are relatively uncommon at an advanced age. Thus, in patients who become ill at an advanced age, spastic pareses of the extremities are the predominating feature during the progressive stage; in a few cases, progressive cerebellar disturbances are present concurrently or alone. Spastic pareses of the extremities are also the commonest feature in a steadily progressive stage of the disease in patients who are young at the onset, although cerebellar symptoms fairly often predominate.

The disease is seldom disabling before it enters a steadily progressive stage, but when this does occur it is as a rule at a low age of onset. Progressive bouts occur earlier with advanced age at the onset, but the rapidity with which the disease

progresses varies only unappreciably with this age. Therefore, older patients become disabled after a shorter duration of illness than do younger ones. The mortality rate also appears to be higher for the older patients.

SUMMARY

A follow-up study of 810 patients with clinically demonstrated disseminated sclerosis showed that the course and prognosis of the disease are, to a great extent, determined by the age at the onset. This conclusion applies, also, in some degree, to the symptoms.

Serafimerlasaretet.

PRECIPITATING FACTORS IN NEUROSES AND PSYCHOSES

Impressions and Reflections During Twenty-Five Years' Observation of a Large Number of Cases, of Which Forty-Five Presented an Uncommon Opportunity for Follow-Up Study to the Present Time

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NOSOLOGICALLY, the series presented the following distribution: (1) psychoneuroses (10 cases); (2) manic-depressive psychoses (14 cases); (3) schizophrenia (5 cases); (4) involutional melancholia (5 cases); (5) depression without delusion (5 cases); (6) psychoses accompanying mental deficiency (6 cases).

In view of the fact that neuroses and psychoses of many years' duration characteristically present episodic outbreaks following physical or emotional stress, the cases under consideration deserve special attention by virtue of the unusual facility for uninterrupted observation over a period of 25 years, since the very onset of the respective disorders. Such a study becomes particularly instructive as it presents a comprehensive, and almost mathematically accurate, material for demonstration of the dynamic forces which form the basis of the disorders. It permits the drawing of correct inferences with regard to the intimate nature of a given affection, the problem of its management, and, especially, the problem of prevention. While the number of cases to be discussed is small, nevertheless, in my opinion, the special circumstances concerning them, viz., the uninterrupted contact with the patients for many years and the similarity of the precipitating factors, justify their being placed on record.

The impressions expressed in this paper may serve at least as confirmatory evidence brought forward by one who has had the unusual opportunity to observe, it may be said, intimately the precipitating elements at different periods over 25 years. The study has the appearance of a genuine laboratory observation, and one made in vivo.

PSYCHONEUROSES

It is quite firmly established that persons who present episodically during their lifetime manifestations of psychasthenia are endowed with a psychopathic constitution. They usually present anomalies of character of various kinds, and their chief characteristic lies in a defective, inefficient adjustment to the environment. The obsessions, imperative impulses, phenomena of special fears, hypochondriacal ideas, fixed ideas, hysterical paroxysms, abulias, states of anxiety, and states of doubt or indecision are all genetic factors at work, but it is undeniable that they occur principally, if not exclusively, in persons with that special make-up that constitutes a neuropathic basis.

A close observer cannot fail to see that in normal life every one of us is subject to the same emotional elements as those which serve as psychogenic agents and still the psychasthenic manifestations are not in evidence. If psychogenic factors are apt to produce abnormal mental phenomena in some persons, it is strikingly evident that such persons are predisposed to morbid manifestations and are readily influenced by factors of a disturbing character. This predisposition that constitutes the psychopathic make-up may be acquired through toxic agents, such as syphilis, alcohol, or tuberculosis, or it may be hereditary. In the latter case there are usually observed either identical or similar psychiatric phenomena in parents or near relatives or some different type of disorder in the domain of cerebral function.

In the psychoneurotic patients of my series an inquiry was made with regard to predisposing factors. In the largest majority a morbid heredity could be traced. Psychoses; alcoholism; constitutional diseases, such as diabetes, pernicious anemia, or gout; malignant neoplasms, and syphilitic manifestations could all be revealed in the family antecedents. Psychoses and various psychiatric manifestations predominated. Some patients presented a personal history of alcoholism or syphilis or both but without a morbid heredity. Others gave morbid family histories combined with personal degenerative elements, such as tuberculosis, alcoholism, syphilis, or protracted malaria.

It is interesting to consider the factors which played an immediate role in the development of the psychasthenic manifestations. It has been mentioned that these manifestations occur episodically in the patient's life. They disappear with or without treatment and reappear. Some of my patients had as many as 10 or 15 recurrences in a period of two or three years. Recurrences are characteristic. The very nature, the fundamental make-up of such persons, is bound to lead to repetition of psychasthenic disorders. These disturbances may repeat themselves exactly or manifest themselves in a different form. Thus, we observe at one time phobias; at another, abulias; at another, doubts or obsessions. Sometimes we observe combinations of two or more forms. It is self-evident that when we deal with a mental state the chief characteristics of which are instability, want of determination, a fundamental inability to adapt to surroundings and circumstances, a deficient manner of reflecting upon one's own conduct and relations to others, defective sentiments and instincts, inability to see things properly and to feel normally, absence of the faculty of proper appreciation of facts, and therefore frequent commitment of errors, absence of good judgment and, consequently, inability to carry out properly, and to the end, plans and projects initiated by themselves or others—want of properly measured initiative and inability to see and concentrate attention upon the main issue of undertaken tasks—when, therefore, we deal with a person presenting such a defective mental constitution, we are to expect the appearance of superimposed mental disorders of a psychasthenic nature at any time during life. A psychopathic make-up stands ever ready to take in and to hold on to disturbances referable to functional nervous manifestations. All that is needed is a precipitating factor. In my cases, the factors that initiated the psychasthenic disorders were all of affective character. Affectivity is the fundamental basis of the personality. It designates painful or pleasurable feeling, mood, and emotion. It controls our actions, and, as Bleuler says, we act only under

the influence of pain or pleasure, and the affects produced by them maneuver our logical reflections; moreover, volition and effort represent but one side, while affectivity is a broader conception. A. Godfrenaux, in his book "Le sentiment et pensée," justly remarks that logic of sentiment conforms to the deep necessities of existence rather than to the cold and rational laws of association of ideas; the affective state is the dominating force, the ideas are only its subjects.

In the affect, therefore, lies the inhibiting or promoting force for ideational complexes. The latter may be crowded out and replaced by others through the affect; and, as Jung expresses it, the strongest ideas, and the ideas that have the firmest hold on the personality, may be totally inhibited by the affect. This is an everyday experience in the life of the normally and of the abnormally constituted persons. The difference lies in the degree of susceptibility to the formation of intense affects. The greater the susceptibility, the greater the emotional force; and the greater is the number of complexes formed. An important feature of the affects to be borne in mind is their perseveration, which is the most powerful factor in constant formation and re-formation of psychical activities in the form of association complexes. The influence of the affect can always be seen in these complexes, which are thus maintained over an indefinite period of time and in which the affect acts as an *agent provocateur*. Under the influence of the weakest stimulus, the affect promptly produces or reproduces complex disturbances. The facility of production of these disorders is highly characteristic of psychoneurotic persons. Such persons possess what Jung designates "complex-sensitiveness." In them the affects are of a highly organized character; in them the perseveration of the affect is exceptionally evident; in them the rapidity of formation and the number of association complexes are extensive; in them we consequently observe recurrences in the same or in other forms of the abnormal psychical activities, which manifest themselves in abulias, deficient will, phobias, doubts, and obsessions in general.

These few considerations concerning the intimate psychological workings explain why in some of my patients 10 or 15 recurrences took place in a period of only two or three years. It is interesting, on the other hand, to take account of the character of the incidents which preceded immediately the onset of the psychasthenic phenomena and acted as stimuli to the highly organized feeling tones which we call "affect." Among such incidents were disappointments of various sorts, occurring against all kinds of expectations; a sudden state of anxiety about the health of a nearest relative or child; sudden fright; loss of fortune or of the ordinary means of livelihood; sudden change in a preexisting physical ailment; the sight of mutilated animals or human beings; séances of spiritualism; séances of hypnotism; dreams of a frightful character; an adverse result of a political election; loss of a position held for several years; fortune telling; an unexpected imprisonment; sudden meeting of creditors; assault and battery.

It may be observed that the largest majority of the patients presented disappointments. It is also curious to note that the greatest number of the disappointing factors were those referable to marital relations, such as a fiancé's abandonment to marry another woman or the husband's abandonment of the wife. Next in order of frequency came loss of affection of children for their parents. The other incidental factors mentioned were almost equally distributed among the remaining

cases of the psychoneuroses. In comparing the psychasthenic manifestations following the two most frequent precipitating factors with those of the other factors, it was noted that the former were more persistent, more profound, more disturbing than the latter. Moreover, combinations of psychiatric disorders were observed in a large number of cases in which the marital or parental factor was operative. Thus, phobias were present in association with folié du doute; obsessions were of a multiple character; hypochondriacal ideas concerned several conditions; in some cases the phobias were of diverse nature; a state of anxiety was very pronounced. This interesting phase in my cases suggested, first of all, that the marital relation in its broadest sense and the parental relation to the offspring are the most deeply rooted and possess great power to impress profoundly the ego complex. Second, it demonstrates with evidence that the stronger the affect, the stronger and more diverse will be the psychasthenic disorder. A neuropathic person dominated by a complex which is under the influence of a powerful feeling tone (affect) will react to powerful stimuli in a stormy manner and create intensive disturbances of a durable character. In explaining why marital disappointments and loss of affection of children for their parents should produce the strongest and most persistent effects, the Freudians will find a basis for consideration of sexual complexes in which the affect is continuously maintained by unsatisfied sexual desire. But another interpretation as well is admissible. Considering the personality in such cases, which, by reason of its psychopathic properties, is unable to assert itself, and considering that in all human beings emotional inhibitions are stronger than the most powerful logic and that in psychopathic persons the predominance of one over the other is still more pronounced, the powerful effect of these precipitating factors, which even in normal life are capable of producing lasting complexes, is readily understood. As complexes extend over thought and force it always in a certain direction, the obstinate persistence and repetition of psychasthenic phenomena are thus explained.

Aside from precipitating incidents, the 10 cases of psychoneuroses presented an interesting feature with regard to sex. It was remarkable to observe that the majority of patients (seven) were women and that there were more unmarried than married ones. Again, the aforementioned precipitating factors, which exercised the most potent influence on the affect and, through the latter on the ego complexes, also, interestingly enough, occurred oftener in women than in men and oftener in mothers than in fathers. Among the other exciting factors which were enumerated séances of hypnotism and of spiritualism had a more powerful disturbing effect on women than on men. It is legitimate, therefore, to conclude that affective states which are the expression of feeling tone are more strikingly developed and more readily responsive in females than in males. As has already been shown, the stronger the affect, the stronger are the complexes and the more frequent are the disturbances thus created in thought and action.

PSYCHOSES

In considering the various psychoses represented in my series, it is interesting to note that the etiological incidents immediately preceding the onset of the mental disorders were not identical in all cases and did not possess the same essential characteristics. The two types of dementia praecox presented great similarity with

respect to precipitating features, and both differed entirely from the other cases. The etiological factors in involutional melancholia and simple depression were also similar. The manic-depressive group stands alone.

Manic-Depressive Psychoses.—The cases of manic-depressive psychoses were singularly interesting. First of all, females predominated, and there were more young than middle-aged ones. Even if the final outcome of these patients' condition is not yet known, the many alternating periods of exaltation and depression which occurred during my observation, viz., over a period of 25 years, were sufficiently characteristic to justify classifying them as under the manic-depressive psychosis, as conceived by Kraepelin. In the largest number of cases incidents of a depressive character preceded the onset of the psychosis. In the young patients, it might be a sudden depressive emotion, such as abandonment by a person whom one intended to marry, sudden depressive news concerning the health of a near relative, disappointment from failure in college examinations, or sudden discovery of marital infidelity, whereas in older persons it was more frequently strong disappointment in undertakings or in business transactions, heavy financial losses, or, oftener, disappointments from inability to meet all the obligations toward the family.

The precipitating elements just enumerated could be considered exciting factors, as they preceded closely the apparent onset of the disorder. It must be borne in mind, however, that disturbing factors of such a nature may occur during the normal life period of almost anyone and still not everyone has a manic-depressive psychosis. A close inquiry into the personal and family antecedents revealed that the greater number of the group presented some, and in certain cases conspicuous, evidence of an underlying condition of a hereditary or personal character which predisposed the patient to the psychosis. Thus, the greater number had exhibited former psychasthenic phenomena, of the most varied kinds—obsessions, phobias, hysterical paroxysms, and choreiform movements. Morbid hereditary histories were obtained for three patients: Insanity, alcoholism, tuberculosis, and various neurotic manifestations were all in evidence. Therefore, for the group with manic-depressive psychosis, factors of a strong psychical character immediately preceded the development of the mental disorder, but a predisposing psychopathic constitution must have been present. All the precipitating factors were of a profoundly emotional character, and were apt to create complexes of a most disturbing nature. In the section on psychoneuroses, the relation of emotional agents to mental phenomena was discussed. Application of these observations to the manic-depressive psychosis will facilitate to a certain extent the understanding of the phenomena observed in this disorder.

Another important feature was encountered in the study of this psychosis. A certain relation could be observed between the alternating phases of the affection and the character of the preceding emotional factors. Thus, the depressive periods were greater in number than the manic periods in the cases of the older persons who had sustained financial losses or of those who found themselves in difficulties in meeting obligations toward their families. On the contrary, the patients whose psychosis was preceded by such factors as marital infidelity or disappointment in matrimonial undertaking presented briefer depressive phases and more prolonged and more frequently occurring periods of a manic state. This observation is interesting from a psychological standpoint, but I shall content myself for the present with merely registering this suggestive observation.

Schizophrenia.—There were five cases of this affection. Four were of the hebephrenic type, and one was of the paranoid type. The greater number of patients gave no history of disturbances immediately preceding the onset of the mental affection, but factors of an exhausting character could be traced. Thus, in three cases the factor of great mental application was observed, such as preparation for college entrance, competitive examinations, or uninterrupted strenuous mental application during the evenings and late at night for months in succession. The last occurred in a case in which the patient was compelled to work manually during the day hours to gain a livelihood. In two cases sexual excesses of an unusual intensity apparently preceded the development of the conspicuous symptoms of the dementia. As dementia praecox is essentially a disease of slow and insidious evolution, it is undoubtedly difficult to determine with any degree of precision whether any of the aforementioned factors could have served as an exciting cause of the disease. Nevertheless, there could be no doubt that the most conspicuous symptoms of the disease began to appear after these factors had been at work for some time. Thus, the disappearance of affectivity and of reaction to external impressions, a break in intellectual capacity, poverty of emotivity, and alteration in voluntary and spontaneous activity and in initiative—symptoms essentially characteristic of the grave affection called dementia praecox—all made their conspicuous appearance and kept on developing progressively after the exhausting elements mentioned above had been in existence. The absence of the grave symptoms of the disease prior to the stimulating effect of these elements makes it reasonably and logically certain that the latter were important precipitating factors. As to the problem of predisposing causes, there was no difficulty in finding an abundance of morbid hereditary factors in every case of the group.

I could find no relation between the nature of the aforementioned exciting causes and the type of the dementia praecox. The same precipitating elements were present in the paranoid and in the hebephrenic form.

As to the sex incidence of the affection, the hebephrenic type was observed almost equally in males and in females.

Involutional Melancholia.—In accordance with the teaching of the Kraepelinian school, as adapted by the majority of writers, this group comprises cases of mental depression occurring in middle life, between the ages of 40 and 60.

The five patients studied especially from the standpoint of etiology presented marked evidences either of a morbid heredity or of individual features of a psychoneurotic type. The most interesting observation was that concerning the incidental factors immediately preceding the onset of the mental disorder. They were all of a strongly emotional and depressive character. The following incidents were observed: loss of a member of the family through protracted illness; anxiety over the health of a child who had been ill for a long period; abandonment of a wife by her husband for another woman, and accidental physical trauma followed by intense fright. The last factor was observed in two cases after a brief period during which general nervous phenomena, such as insomnia, fear, or tremor, were in evidence; mental depression followed.

In the cases of melancholia the relation of the emotional factors to the mental affection was manifestly closer than in any other psychosis previously studied. In some cases the former sound mentality was strikingly affected by the depressing

events enumerated above almost immediately or soon after their occurrence. The presence or absence of the unsystematized delusions bore no relation to the character of the preceding etiological events, but the degree and the intensity of depression were in direct proportion to the intensity of the exciting factor and to the personal affectivity of the patient. Thus, loss of children had in one case a profound influence on the intensity of the depression and, curiously, on the duration of the affection. In the few cases of this character at the time of writing the patients have not yet recovered, and their mental affection has been in existence many years. Here, evidently, the action of the strong emotional factors on the psyche was such that a new complex appeared very prominently and crowded all the others into the background with an extraordinary persistence. Perseveration, which is so characteristic of the affect, in addition to the great emotional force which was present in the cases of persistent depression, contributed to the formation of lasting complexes.

Of the five patients with melancholia, four were women and one a man. The occurrence of melancholia in women at the age of involution of the reproductive organs is not infrequent. Although a climacteric period exists in man, the high frequency of melancholia in middle-aged women speaks in favor of the theory that the disturbed physiological function of the ovaries is at least one of the etiological factors in the mental disorder.

Depression Without Delusions.—In this group were not included cases of involutional melancholia or cases typical of manic-depressive psychosis. First, the entire group of five patients was composed of young persons, from 16 to 32 years of age. Next, during the observation period they all had attacks of depression accompanied or unaccompanied by a state of anxiety. The question arises: Were the attacks of depression manifestations of the manic-depressive psychosis, or could they be considered a separate and independent mental state?

The fact that the depressive state existed for many weeks or months, that it was accompanied by a state of anxiety and in some cases by obsessions, but at no time by delusions or hallucinations; that the period of depression was not followed by one of a manic state or by another period of depression during several years of observation; and, finally, that the character of the depression was not profound enough to lead the patient to despair and abandonment—all these circumstances permitted the classification of these patients as having independent states of depression which had nothing in common with the depressive characteristics of involutional melancholia or of the manic-depressive psychosis.

The following factors were observed to be etiologically connected with the depressive states: sudden misfortune occurring in the family of the nearest relatives, such as death or acute disease; disappointment in love; fear of becoming insane; fear of having tuberculosis or cancer; fear of extreme poverty because of loss of position, and fear of the dependent family's becoming destitute. While these etiological factors immediately preceded the development of the depression with or without anxiety, powerful predisposing factors could be traced in every case of this series. Functional nervous diseases, insanity, or alcoholism was present either in the family or in the patient himself. The intensity and duration of the depressive state were apparently directly related to the character of the precipitating factor and to the affectivity of the given patient. The considerations mentioned in the discussion on the psychoneuroses with regard to the role played by the feeling-tone in the formation of complexes find their application here.

This group of patients with depressions consisted of three females and two males. Disappointment in love affairs was the predominating factor. Calamities occurring to the nearest relatives and fear of poverty—these two factors had their greater effect on men than on women.

PSYCHOSES ACCOMPANYING MENTAL DEFICIENCY

Of the six mentally defective patients, three presented at various times during the observation period manifestations of a psychasthenic order. Obsessions of hallucinatory character, phobias, states of anxiety—all were present at various intervals. Curiously, shock of a most trifling character, especially sudden fright, was practically the only exciting cause of the psychasthenic phenomena. The uniformity of reaction to this precipitating factor was striking.

More interesting, however, are the remaining three cases, in which symptoms characteristic of genuine psychoses were observed, the condition in one case simulating dementia praecox, especially the paranoid form, the second presenting the manic-depressive type, and the third, hallucinations of auditory and visual character without delusions.

Without entering into a detailed description of these various conditions, which, although of the highest psychiatric interest, are not the subject of the present contribution, I shall consider briefly their general characteristics, such as were observed in my six cases. The most conspicuous features were the sudden onset of the mental disorder, its brief duration (from a few days, in the manic-depressive form and in hallucinosis, to a very few weeks, in the dementias), and rapid, or even sudden, termination. In the case of the dementia praecox type there were several brief attacks, and each attack of the superimposed mental disorder ended in complete recovery.

Another characteristic feature of the incidental psychoses in mentally defective persons is the shallowness and the lack of depth of the individual manifestations of the psychoses. Depressive states of anxiety, delusive ideas, hallucinatory images are all superficial and do not affect the patient's consciousness profoundly enough to alter substantially his mode of thinking, feeling, and acting.

In considering the precipitating factors, which was the chief object of the present study, I found that the provocative causes of the psychoses associated with mental deficiency were all of a physical character.

Alcohol, excessive use of cigarettes, and masturbation were the three principal factors which immediately preceded the onset of the superimposed psychiatric disorders. Chronologically, there was a strikingly direct relation between those agents and the disturbance. It is interesting to note that in the psychoses associated with mental deficiency one does not find etiological factors of a purely psychical character, which were so conspicuously present in patients with a normal mentality in whom psychiatric disturbances developed. Evidently, there is a fundamental difference in the affectivity and in the influence of the affect on the formation of ideational complexes in persons of a normal and in persons of deficient mentality. The elements of psychical life, namely, sensations, emotions, and ideas, which form the essential basis of the personality, are evidently different in persons of the two categories. The psyche of mentally defective persons does not undergo the same influences when complexes increase or decrease in intensity.

CONCLUSIONS

A glance at the individual forms of psychiatric disorders described in the present study shows most conspicuously a certain relation between these disturbances and the incidents immediately preceding them. While in the majority of instances these incidents can in no way be considered the fundamental causative factor in the psychiatric disorders, because of the profoundly pathological nature of the patient's mental make-up, nevertheless, in view of the onset of the disturbances immediately or soon after the appearance of the incidental factors, and in view of the emotional character of the incidents, which in themselves must have had a powerful influence on the affectivity and, through this, on the formation of ideational complexes, for all these reasons, an affective relationship must unhesitatingly be admitted. Thus, we see that the vast field of preventive medicine may legitimately include the domain of psychiatry. Mental disorders do occur in consequence of disturbing factors of a special nature, namely, such as are capable of influencing the feeling-tone of persons whose mentality is potentially unstable by reason of hereditary or individual morbid predisposition. Persons of such a pathological make-up are inevitably prepared to manifest mental disorders at any period of their lifetime, but if by proper and judicious measures factors of a pronounced emotional significance can be avoided, the psychiatric collapse may be prevented entirely, or at least indefinitely, postponed. The predominant influence of some precipitating factors over others in initiating a mental breakdown is not only psychologically interesting but also of the highest practical importance.

TYPES OF CENTRAL AUTONOMIC INNERVATION AND FATIGUE

Pupillographic Studies

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IN EARLIER investigations [1] it was found that (1) reiterated elicitation of a single autonomic reflex or (2) hard work by which the subject was generally fatigued resulted in disintegration of central autonomic mechanisms of control. When the pupillary reflex to light was fatigued and finally exhausted by repeated stimuli, two related sequences of events occurred:

(*a*) In the periphery, a gradual, although rhythmically interrupted, disintegration of the reflex shape. Certain types of reflex shapes appeared and were described as shapes of slight disinhibition of contraction, the tonohaptic reflex, W- and V-shapes, sluggish and inextensive contraction, prolonged latency periods, and absence of the reflex.

(*b*) In the centers of autonomic control, corresponding processes of disintegration, the sequence of which was expressed in a general law: "All nervous fatigue is central in origin; the sympathetic centers fatigue prior to the parasympathetic centers, the cortical prior to the subcortical."

All fatigue shapes which, transitorily and reversibly, appeared as symptoms of physiological fatigue could be observed as permanent manifestations of organic lesions at the different levels at which, normally, the reflex to light is integrated in the nervous system (law of analogy [2] between physiological fatigue and pathological processes).

The disintegrated, or even exhausted, autonomic reflex activity can be reintegrated at any moment by psychosensory stimulation (psychosensory restitution

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1. Lowenstein, O., and Loewenfeld, I. E.: (*a*) Disintegration of Central Autonomic Regulation During Fatigue and Its Reintegration by Psychosensory Controlling Mechanisms: I. Disintegration; Pupillographic Studies, J. Nerv. & Ment. Dis., to be published; (*b*) Disintegration of Central Autonomic Regulation During Fatigue and Its Reintegration by Psychosensory Controlling Mechanisms: II. Reintegration; Pupillographic Studies ibid., to be published.

2. (*a*) Lowenstein and Loewenfeld.[1a] (*b*) Lowenstein, O.: Der psychische Restitutionseffekt. Das Prinzip der psychisch bedingten Wiederherstellung der ermüdeten, der erschöpften und der erkrankten Funktion, Basel, Benno Schwabe & Co., 1937.

phenomenon [3]) or its neurological equivalent,[4] i. e., sympathetic stimulation. Reintegration is performed in a sequence which is the reverse of the one observed during disintegration: "Restitution from fatigue is central in origin; subcortical centers defatigue prior to cortical centers, the parasympathetic prior to the sympathetic" (general law of restitution [1b]).

The linear decline of autonomic reflex activity during fatigue is rhythmically interrupted by periods of slight recovery; they are manifestations of the psychosensory restitution phenomenon and are activated by psychosensory stimuli which result from conscious or subconscious sensations produced by the fatigue process itself. Fatigue feelings, thus, were shown to be an integrative part of fatigue processes; they rhythmically elicited restitution and thereby—in a manner similar to that of negative feed-back mechanism—delayed exhaustion (special law of restitution [1b]).

The shape of each individual reflex to light is an indicator of the degree to which the centers of control are disintegrated; it therefore is a measure of the actual condition of fatigue at the moment of reflex elicitation.[1] The length of the rhythmically appearing periods of decrement and increment of autonomic (pupillary) reflex activity and the rate of deterioration of the reflex to light within each period are a measure of fatigability.[1b]

Methods by which fatigue and fatigability could be measured have been the key to all investigations ever since research on the subject of fatigue started. Arnold Durig,[5] one of the classic investigators of fatigue, stated that there exist very few methods in experimental physiology and psychology which have not actually been used for the study of fatigue. He wrote:

> However, there is not even one method known at this time which makes possible quantitative measurement of the degree of fatigue in a living human being. . . . Such methods are unlikely ever to be found, since we shall always be able to measure only one or another symptom accompanying or following fatigue. Only in the case that fatigue could be presented as a chemical or physical process would it perhaps be possible to measure fatigue by measuring this process. This, however, would be equivalent to solving the problem of measuring life itself, because fatigue is, essentially, a diminution of the capacity of the living substance to manifest life.

In applying the general principles of disintegration of central autonomic regulation by fatigue and its reintegration by psychosensory steering mechanisms to the practical problem of measuring fatigue, we encountered a certain number of new problems. In healthy persons, individual differences of fatigue and fatigability before and after work were found which were not in proportion to the general muscular condition present. In some cases, symptoms of pupillary fatigue following reiterated light stimulation appeared prematurely; in other cases they were delayed. Discrepancies seemed to exist in the rate of fatigue produced by reiterated stimuli of high and of low intensity.

The purpose of this article is to report investigation of the principle behind this variety of responses. This task is not unlike the one faced by pharmacologists who

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3. Lowenstein.[2b] Lowenstein and Loewenfeld.[1b]

4. (*a*) Lowenstein, O., and Loewenfeld, I. E.: Role of Sympathetic and Parasympathetic Systems in Reflex Dilatation of the Pupil, Arch. Neurol. & Psychiat. **64**:313-340 (Sept.) 1950; (*b*) footnote 1b.

5. Durig, A.: Die Theorie der Ermüdung, Leipzig, Georg Thieme, 1927.

have to explain differences in the effects of the same drug in different subjects, in the same person at different times, and the different, seemingly qualitative, effects of different quantities.

The following questions arise:

1. Do different types of sympathetic-parasympathetic equilibrium exist in normal persons? If they do, how are they characterized, and how do they differ from pathological conditions?

2. What are their relations to fatigue and to fatigability?

3. How may the differences between the effects of low and of high intensity stimuli, and of light and of hard work, on fatigue and fatigability be explained?

METHOD

These problems were approached by pupillographic methods, as described in earlier publications.[6] All experiments were made on men. Long series (an average of 70 reactions) of pupillary reactions to light were recorded. The eyes had previously been adapted to either dark red-infrared illumination or to diffuse room illumination of average intensity with the indirect light source behind and above the subject. The light stimuli used were of average (15 f.-c.), high (90 f.-c.), and low (4 to 0.2 f.-c.) intensity. A Wratten (K2) green filter was used in front of the stimulating light (tungsten).

About 160 series were recorded. Most of the subjects (20) who were tested, before and after work, were familiar with the procedure and had previously been examined repeatedly. This group of subjects consisted of physicians, medical students, and laboratory and office workers.

All experiments were performed with psychological precautions, previously described.

RESULTS

I. Pupillogram of Reflex to Light in Clinical Cases of Parasympathetic and Sympathetic Damage

A. Normal pupillogram and Differential Curve of the Reflex to Light in Man.—These were described in an earlier publication.[1a] Just as for cats and monkeys, the pupillogram consists of (Fig. 1*B*) (1) contraction, preceded by a latency period of about 0.2 second (a fast primary and a slower secondary phase of contraction can be distinguished) and (2) redilation, likewise consisting of a fast primary and a slower secondary phase.

The differential analysis shows (Fig. 1*B*[1]) the following changes:

1. C-wave (contraction wave), the ascending branch and peak of which correspond to the primary contraction phase of the pupillogram and are predominantly due to parasympathetic reflex activity. The descending branch corresponds to the secondary contraction phase of the pupillogram and is due to parasympathetic reflex activity but is shaped by the increasing influence of the antagonistic sympathetic.

2. D-wave (primary redilation wave), predominantly due to parasympathetic relaxation.

3. E-wave (secondary redilation wave), depending mainly on impulses which probably come from Area 8 of the cortex and run over the peripheral sympathetic fibers.

When experimental lesions were produced in cats and monkeys, the pupillograms and differential curves were modified in extent, duration, and timing. These modifications were identical with those in man with clinical lesions of analogous sites

6. Lowenstein and Loewenfeld.[1] Lowenstein.[2b] Lowenstein and Loewenfeld.[4a]

B. Central Parasympathetic Lesion.—In cases of experimental partial lesions of the third nerve nucleus in monkeys,[7] the following changes in the reaction to light were observed:

1. Contraction and redilation were sluggish and inextensive.

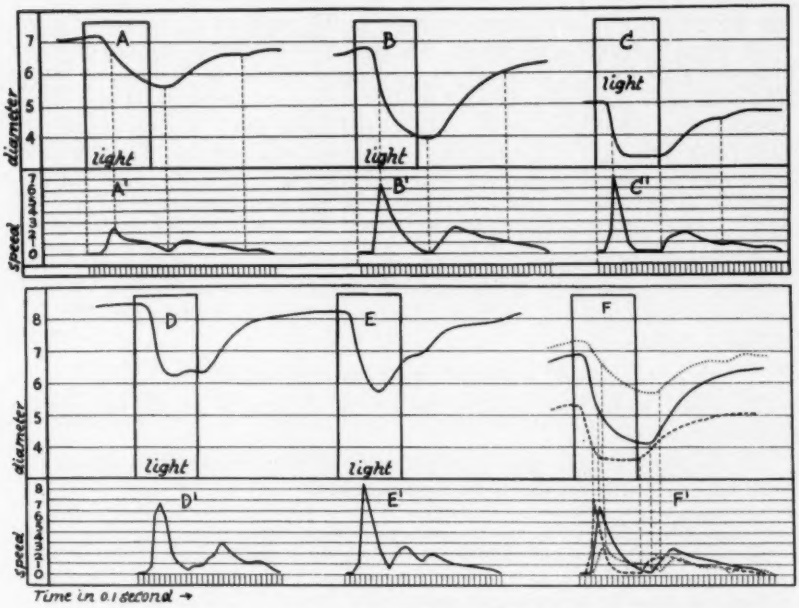

Fig. 1.—Normal and pathological pupillary reactions to light stimuli of average intensity.

In the pupillograms (*A*, *B*, *C*, *D*, and *E*) pupillary diameter is plotted (in millimeters) against time (in 0.1 second). Contraction and redilation consist of a fast primary and a slower secondary phase.

In the differential curves (A^1, B^1, C^1, D^1, and E^1) contraction and redilation within each successive tenth of a second (0.1 mm.) are plotted against time (in 0.1 second). Contraction and redilation consist of different waves, of increasing and decreasing speeds of motion: C-wave (contraction wave) and D- and E-waves (dilation waves).

B and B^1, pupillogram and differential curve of the normal reflex to light.

A and A^1, nonirritative lesion of the third nerve nucleus. The pupillogram (*A*) shows a large pupil, increased latency period for contraction, inextensive and sluggish contraction, and redilation. In the differential curve (A^1) this is expressed by low and delayed peaks of movement.

C and C^1, central sympathetic lesion. The pupillogram (*C*) shows a smaller-than-normal pupil, a shorter-than-normal latency period, and fast contraction (tonohaptic reaction shape). In the differential curve (C^1,) this is expressed as an earlier and higher peak of the C-wave, which quickly drops to zero.

D andD^1, W-shape of the reflex.

E and E^1, V-shape of the reflex in a case of central sympathetic irritation. The differential curve shows that the peaks of the C-waves are not reduced, since the parasympathetic response is unimpaired.

F and F^1, comparison of *A*, *B*, and *C* and A^1, B^1, and C^1, showing the time relation described above. The solid line represents *B* and B^1; the broken line, *C* and C^1; the dotted line, *A* and *A*.

7. Lowenstein, O., and Loewenfeld, I. E.: Mutual Role of the Sympathetic and Parasympathetic in Shaping of the Pupillary Reflex to Light: Pupillographic Studies, Arch. Neurol & Psychiat. **64**:341-377 (Sept.) 1950.

2. The latency period preceding contraction was prolonged.

3. C- and D-waves were low and delayed (shifted to the right on the time axis).

Figure 1*A* shows the pupillogram of a 14-year-old boy with congenital syphilis of the central nervous system and the clinical picture of a lesion of the third nerve nucleus, with positive Wassermann reactions of the blood and cerebrospinal fluid but otherwise normal neurological findings. In the pupillogram, the latency period is prolonged to more than 0.3 second. The contraction is sluggish and less extensive than normal (1.4 mm.); redilation, too, is sluggish and of less than normal extent. The differential curve shows that the speed of contraction during the primary phase (ascending branch of the C-wave) is diminished, rising slowly to a low and delayed peak (shift to the right on the time axis); the secondary contraction phase (descending branch of C-wave) is relatively well preserved; the contraction speed decreases slowly from its peak. D- and E-waves also rise and decline slowly; they have low peaks and are shifted to the right.

C. Central Sympathetic Lesion.—In monkeys with experimental lesions in the posterior hypothalamus or in the midbrain cephalad to the third nerve nucleus [7] irreversible tonohaptic reaction shapes appeared. They were bilateral and characterized as follows:

1. The latency period [8] is normal, or shorter than normal.

2. A fast contraction is performed almost exclusively during the primary contraction phase.

3. The pupils remain immobile at full contraction for several tenths of a second, until some time after the end of the light stimulus.

4. Redilation is fast.

5. The differential curve shows an earlier and a higher peak of the C-wave, which drops quickly to zero and well-developed D- and E-waves. The entire differential curve is shifted toward the left.

Figure 1*C* shows the pupillogram of a woman aged 42 with a diencephalic (postencephalitic) condition. Tonohaptic reactions are well developed.

D. Central Sympathetic Irritation.—In excited monkeys [7] the reaction to light changed in both shape and extent. With increasing excitement, W-shapes; V-shapes; delayed, inextensive, and sluggish reactions, and, finally, complete contraction block were observed. Clinical cases exist—and are not infrequent—in which the sympathetic system is more irritable than normal. The excitement shapes of the reflex are due to a central condition, which generally manifests itself by a variety of signs of sympathetic hyperirritability, existing either permanently, i. e., throughout life, or as symptoms of a neurosis or psychosis. They may appear as a preliminary stage in the development of an organic sympathetic lesion (tonohaptic reaction). As a transitory condition of short duration, they may be evoked in any normal person under the influence of emotions of some intensity. In extreme cases (catatonia, hysteria) the condition may lead to more or less complete block of the contraction to light. In milder cases, the reflex to light is preserved. The pupillographic signs

8. The original conception (Lowenstein, O., and Westphal, A.: Experimentelle und klinische Studien zur Physiologie und Pathologie der Pupillenbewegungen, Berlin, S. Karger, 1933) that the latency period for contraction was prolonged cannot be maintained in the light of recent research, done with more accurate timing controls.

are those of a mydriatic pupil (7 mm. or more after adaptation to dark red-infrared illumination) and the constant appearance of excitement shapes of the reaction to light, such as W- and V-shapes (Figs. 1*D* and *E*).

II. Types of Autonomic Regulation and Fatigue

So-called normal, healthy persons usually exhibited fatigue shapes of the reaction—in answer to repetitive light stimuli—not only in a certain order, but also at a certain rate; they did not show drastic changes in the reflex shape within the first three reactions.[1a] Other seemingly normal persons manifested fatigue symptoms prematurely. While in all of them the first reaction was normal, frequently in response to the second or third stimulus reactions were observed which showed tendencies toward, or full development of, shapes just described as pathological. In some cases they showed the types of central sympathetic weakness (tonohaptic reactions); in others, those of sympathetic irritation (W- and V-shapes). These pupillograms are distinguished from pathological ones by the fact that the first of a series of reactions to light is normal, whereas in truly pathological conditions even the first reaction is abnormal; i. e., irritation or fatigue reaction shapes are always present.

The normal reflex to light is integrated at different levels of the nervous system; lesions at these levels result in specific changes of the reaction shape. Irreversible occurrence of certain reaction shapes points to a lesion of the specific site. Likewise, the type of prematurely occurring reversible fatigue reactions points to a specific level in the nervous system as the site of functional weakness.

Type 1: *Syntonic Reaction Type of the Well-Balanced Normal Person.*—As representative of this type, a series of reactions to light in a physician, aged 55, in good physical and mental health is shown. Physically, he is of asthenic type. He has never been seriously ill and is indefatigable; for years he has been able to work through half the night without noticeable signs of fatigue the following day. He has a well-balanced and pleasant personality and is even-tempered and unchanged under considerable and long-lasting stress. His pupillary reactions, both in the direct pupillogram (Fig. 2*A*) and in the differential analysis (Fig. 2A^1), are normal in shape, extent, duration, and course of fatigue.[1a] The only fatigue signs which developed within the first three reactions consisted of a slight weakening of the sympathetic factor, resulting in (1) a slight increase in the primary contraction phase and a corresponding decrease in the secondary contraction phase, and (2) in the differential curve, a moderate increase in the peak of contraction speed (C-wave), a slightly faster decline of the descending branch of the C-wave, and a slight tendency toward a shift to the left.

Type 2: *Reaction of Central Sympathetic Irritability in the Hyperactive Normal Subject.*—As representative of this type, a series of reactions to light in a physician, aged 26, in good physical and mental health is selected (Fig. 2*B*). As compared with the subject of Figure 2*A*, he is excitable and restless, overactive, and enthusiastic. He is always in a good mood, always busy and full of ideas, without ever having shown any signs of pathological imbalance, either of a manic or of a depressive type.

The first pupillary reaction to light is normal, both in the pupillogram and in the differential curve derived from it. However, the second reaction already shows a W-shape, and the third reaction, a V-shape; both are the expression of central sympathetic irritation (Fig. 2 *B* and B^1).

Type 3: *Reaction of Central Sympathetic Weakness.*—This type is represented by a medical student, aged 24, in good physical and mental health. He is very intelligent and reports that he is easily fatigued by either physical or mental work. Nevertheless, he works hard and steadily, is conscientious, concerned with his future, sensitive, and reliable.

The first pupillary reaction to light is normal (Fig. 2C and C^1). In the second reaction to light, the primary contraction phase is increased (higher peak of C-wave), and the secondary contraction phase falls off more sharply. In the third reaction these tendencies are enhanced, resulting in a tonohaptic reaction shape.

TYPE 4: *Reaction of Central Sympathetic Irritative Weakness.*—This type is closely related to Type 3, from which it is distinguished by the early and frequent occurrence of excitement shapes (W- and V-shapes) of the reflex, followed by premature tonohaptic reactions.

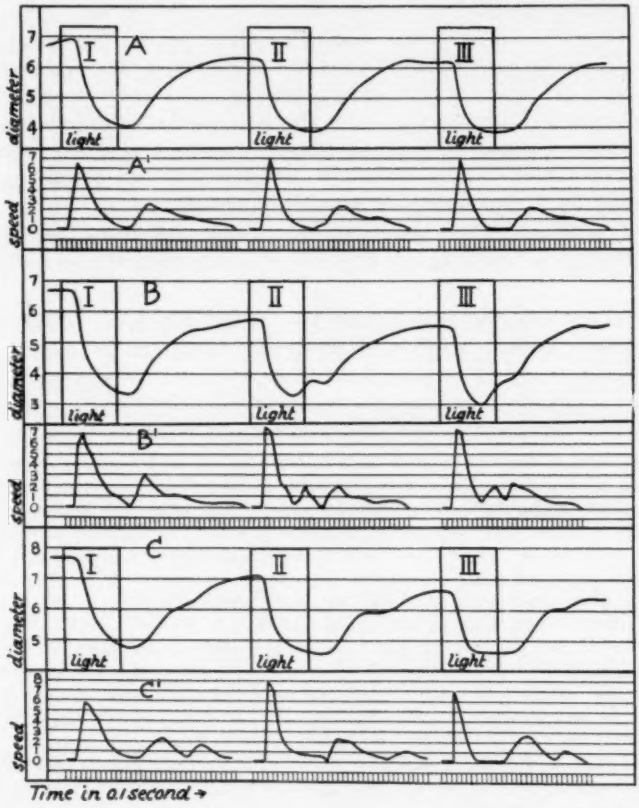

Fig. 2.—Influence of reiterated light stimuli on the various types of autonomic equilibrium.

A and A^1, pupillogram and differential curve of three reactions to light in a well-balanced normal subject.

The first fatigue symptoms produced by three successive light stimuli appear; they consist of a slight increase and shifting to the left of the ascending portion of the C-wave at the expense of the descending portion, which declines faster (slight weakening of the sympathetic activity).

B and B^1, pupillogram and differential curve of three reactions to light in a hyperactive normal subject.

The first reaction to light is normal; the second reaction already shows the W-shape, and the third reaction the V-shape, of the reflex.

C and C^1, pupillogram and differential curve of three reactions to light in the normal subject with functional weakness of the sympathetic nervous system.

The first reaction to light is normal; in the second reaction the tendencies described in *A* are exaggerated; the third reaction already shows tonohaptic shape.

III. Effect of Parasympathetic (Light) Stimuli of Various Intensities in Different Types of Central Autonomic Regulation

In normal persons, under standard light conditions, shapes of light reaction characteristic of lesions of the third nerve nucleus are not found except in long fatigue series, but they are regularly produced by light stimuli of low intensity (1 f.-c. or less).

Figure 3 shows five series of experiments made on the same normal subject, a woman aged 24, in good physical and mental condition. She has a well-balanced personality; as an autonomic reaction type, she belongs to Type 1 (syntone).

In *A*, *B*, *C*, and *D* of Figure 3, the pupillary reactions to light were elicited by light stimuli of graded intensities (90 f.-c. in *A*, 15 f.-c. in *B*, 4 f.-c. in *C*, and 0.2 f.-c. in *D*) after the eyes had been adapted to dark red-infrared illumination

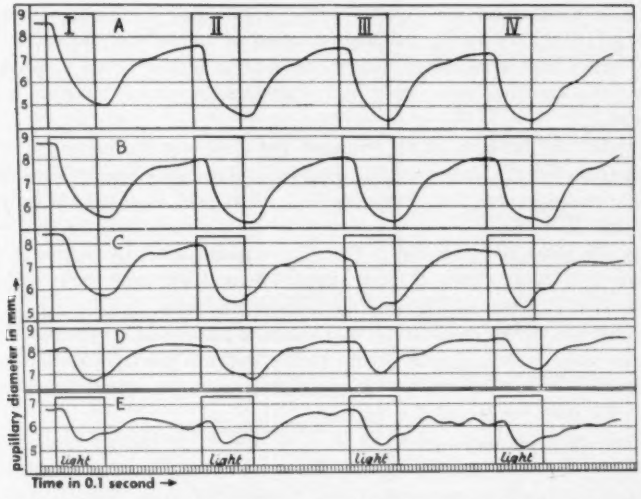

Fig. 3.—Pupillary responses to four successive light stimuli of various intensities in a normal well-balanced subject (syntone reaction type).

In series *A*, *B*, *C*, and *D*, the pupil had been adapted to dark red-infrared illumination, and in series *E*, to ordinary diffuse room illumination. The intensity of the stimulating light amounted to about 90 f.-c. (*A*), 15 f.-c. (*B*), 4 f.-c. (*C* and *E*), and 0.2 f.-c. (*D*). A Wratten (X2) green filter was used in front of the stimulating light.

A and *B*: The pupillary response remains normal through the first three reactions, only the fourth reaction showing a tendency toward formation of a W-shape.

C: In the first reaction, the latency period is slightly prolonged, and the contraction, slower and less extensive; the second to fourth reactions show increasing development of the W-shape.

D: The latency period is further prolonged, and extent and duration of the sluggish contraction are further reduced. All reactions show shallow W- and V-shapes.

E: The light-adapted pupil is smaller than in the series *A* to *D*. Reactions to light show W-shapes throughout. Although the extent of the reactions is reduced as compared with those in response to the same intensity of stimulus while the subject was in darkness (*C*), the latency period is not as long as, and the contraction is faster than, that in series *D*. There are fast oscillations of the pupillary diameter (particularly visible between the third and the fourth reaction), which are not seen when the pupil of a normal person is adapted to darkness.

In *E*, the reactions were elicited by stimuli (4 f.-c.) of the same intensity as in *C* after the eyes had been adapted to average diffuse room illumination with the light source behind and above the subject.

In all experiments a Wratten X2 (green) filter was used in front of the stimulating light.

Already, at first glance, great differences in the resulting reflexes are noted. The reactions of Figure 3*A* appear extensive; those of Figure 3*D* and *E*, inextensive.

Upon detailed analysis, it is found that the series of Figure 3*A* show the most extensive reactions and their shapes are more evenly preserved than those of the following series of experiments. *B* of Figure 3 shows a W-shape in the fourth reaction; *C*, shows premature redilation in the second, a W-shape in the third, and a V-shape in the fourth, reaction to light. In Figure 3*D*, shallow V- and W-shapes are observed throughout. In *E*, fast oscillations, superimposed on the entire curve, are seen in addition to W- and V-shapes of the reactions to light.

As the light stimulus is reduced, the latency periods increase, and the contractions become slower.

The differential analysis (Fig. 4) further shows that the highest intensity of stimulus (*A*) does not create the highest speed of contraction; however, a high speed of contraction is sustained longer (descending branch of the C-wave) than in reactions to stimuli of lower intensities; therefore the total contraction is largest in series *A*.

The higher the intensity of the stimulus, the greater is the increment of speed of the reaction. This is illustrated in Figure 4*G*. Within 0.4 second after the start of the light stimulus, reaction *A* reaches 97% of its peak of speed; *B*, only 74%; *C*, 48%, and *D*, 15%.

Figure 4*E*, showing a reaction to the same stimulus intensity as that in Figure 4*C*, reaches 64% of its maximal speed after 0.4 second, although the reaction is no more extensive than that of Figure 4*D*, as shown in *H* and *I*.

It is therefore shown conclusively that the total amount of contraction does not influence its slope, which, like the latency period, depends primarily on the intensity of the stimulus, and secondarily on the sympathetic-parasympathetic balance of the subject at the time the stimulus is applied.

While in the experiments of series *A*, *B*, *C*, and *E* the highest speed is always reached after 0.5 second, it is delayed to 0.6 second in the low intensity experiment, just as in clinical cases of parasympathetic insufficiency (Fig. 4*G*).

This means that normal persons at low intensity stimulation act in the same manner as persons with third nerve damage do under standard conditions. The stronger the light stimulus, the more sustained the contraction, leading to a more extensive total reflex. The same is true of redilation. The stronger the stimulus, the faster (in millimeters per second) and more sustained the redilation. In low intensity stimulation, redilation takes place prematurely but lacks the speed and duration seen in high intensity stimulation.

The general influence of a higher level of pupillary adaptation (general illumination), as compared with the condition of darkness, consists of a constant stimulation of the parasympathetic.

Figure 5 shows the same series of experiments in a man aged 20, in good physical condition. He is somewhat excitable, although well controlled. He represents Type 2 (functional central sympathetic irritation). Even in response to the highest intensity of stimuli (*A*), tendencies toward formation of a W-shape appear as early as the second reaction. The W-shape is quite apparent at the third reaction of series *B* and is present even at the first reaction of series *C*. The

reactions in low intensity series (D) decrease faster than in the high intensity series (A), while a depressing effect of the higher level of adaptation (compare C and E) is absent.

Figure 6 shows the same series of experiments in a case of Type 3 (functional central sympathetic weakness). This case was described above and shown in Figure 2C.

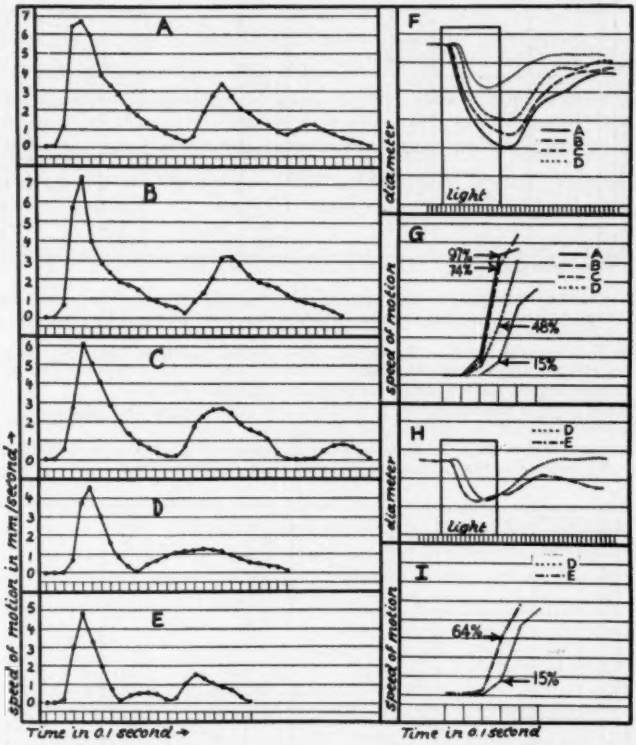

Fig. 4.—Differential analysis of the pupillary responses to stimuli of various intensities in a normal well-balanced subject.

A, B, C, D, and E: Differential curves of the first reaction to light of each of the corresponding series of reactions shown in Figure 3. High contraction speeds in the descending branch of the C-wave are maintained longest in A, accounting for the more extensive contraction, although the peak of contraction speed is not higher than in B.

In C and D, the peak of the C-wave is increasingly reduced and delayed.

In E the C-wave is reduced but not much delayed.

F: Superimposed pupillograms of the reactions A, B, C, and D, showing the difference in latency period and angle of contraction.

G: Superimposed differential curves (ascending branch of C-wave) of the reactions A, B, C, and D, showing the varying increment of speed.

H: Superimposed pupillograms of the reactions D and E. Although the extents of the two reactions are the same, D, is delayed as compared with E.

I: Superimposed differential curves of the reactions D and E (ascending branch of C-wave) showing the different increments of speed.

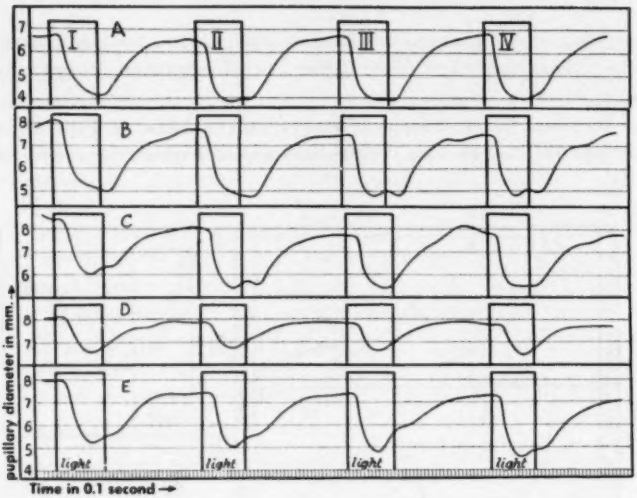

Fig. 5.—Pupillary responses to four successive light stimuli of various intensities in a person with functional irritation of the central sympathetic. The same light conditions as those described in Figure 3 were used.

A: The first reaction to light is normal. The second and third reactions show a slight tendency toward formation of the W-shape.

B: A pronounced W-shape develops in the third and fourth reactions.

C: Already the first reaction shows a W-shape; the third reaction, a V-shape.

D: Shallow V-shaped reactions appear throughout.

E: The depressing effect of the room illumination seen in Figure 3, as well as the fast oscillations, are not seen. The reactions show W- and V-shapes throughout.

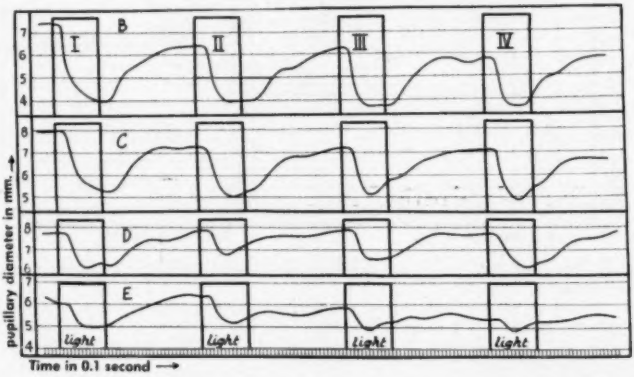

Fig. 6.—Pupillary responses to four successive light stimuli of various intensities in a subject with functional weakness of the central sympathetic. The same light conditions as those described in Figures 3 and 5 were used. The high intensity series (*A*) is missing.

B: Although the first reaction is normal, fatigue is increased. Already, the second reaction shows a tendency toward development of a tonohaptic reflex shape; the fourth reaction, a V-shape.

C: Increasing development of the W-shape begins with the second reaction.

D: The low intensity series shows less fatigability than in Figures 3 and 5, or than in the high intensity series in the same subject (compare the first and fourth reactions).

E: The depressing effect of the room illumination is more pronounced than in Figures 3 and 5, causing inextensive reactions and increased fatigue.

As in cases of Types 1 and 2, the intensity of the light stimulus influences the extent and shape of the reactions. As compared with Type 1, fatigue phenomena (of sympathetic weakness) are more pronounced in series *B* (16 f.-c. intensity). Already, the second reaction shows a strong tendency toward the tonohaptic shape, with the fourth reaction noticeably diminished and V-shaped. In contrast to these findings, the low intensity reactions do not fatigue more quickly than in Type 1, while a higher level of adaptation (series *E*) has a much more depressing effect.

Figures 3, 4, 5, and 6, therefore, are indicative of the following facts:

1. Reactions to high intensity light stimuli generally are more extensive and faster than are reactions to low intensity light stimuli.

2. The latency period increases as the intensity of the stimulus decreases. The longest latency periods and the slowest increase of contraction speed (as shown in the differential curve) are found in response to the lowest intensity of stimulus.

3. Reactions to low intensity stimuli and reactions to high intensity stimuli fatigue evenly in normal cases of Type 1 (syntonic).

4. Reactions to low intensity stimuli fatigue more quickly than reactions to high intensity stimuli in cases of functional sympathetic irritation (Type 2).

5. Reactions to low intensity stimuli fatigue less quickly than reactions to high intensity stimuli in cases of functional sympathetic weakness (Type 3).

IV. Fatigue and Fatigability of Pupillary Reflex to Light Before and After Work

All pupillograms of long series of reactions to light contain rhythmic waves of increment and decrement of function.[1b] They include all the factors of fatigue and defatigue, such as pupillary size, extent, speed, and duration of contraction, which govern the shape of the reflex.

It was stated before [1b] that this rhythm becomes more pronounced as general fatigue of the subject advances; it is most developed when the person is about to fall asleep. As fatigue sensations become stronger and more conscious and sensations of sleepiness develop, volitional efforts to keep awake counteract fatigue and/or sleep; they interrupt, or coincide with, the preexisting natural rhythm.

Whereas extent and shape of the individual reflex to light are a measure of the fatigue present, the duration of the rhythmic periods and the rate of deterioration of the reflex to light within each period are a measure of fatigability.

This is illustrated in the case of a man, aged 35, who was fatigued to the point of exhaustion by 27 hours of uninterrupted strenuous mental work during a hot summer period. While the first four reactions to light were normal (Fig. 7), fatigue developed rapidly and was rhythmically interrupted by the spontaneous efforts of the subject to keep awake. The reflexes deteriorated faster in each successive period of the rhythm. The awakening impulses rapidly lost their effectiveness and resulted in decreasingly complete restitutions, followed by faster deterioration of function and, therefore, shorter periods of the rhythm. When spontaneous restituting impulses became ineffective, they were substituted for by sensory stimuli (blowing into the face of the subject), which finally became ineffective too, and the subject fell asleep.

It is evident that any human being can be fatigued to the point of exhaustion if the fatiguing work is continued for a sufficient length of time. Usually, this occurs

only in emergency situations, which are difficult to imitate experimentally. Since exhaustion is not a feature of daily life, it seems, for practical purposes, more important to ascertain the effect of a given amount of work, such as an eight-hour working day, on the different types of persons (Section II).

None of the subjects examined were heavy laborers. They were physicians, nurses, and secretaries.

A. The Well-Balanced (Syntone, Type 1) Subject Before and After Work.—The subjects in this group did not feel exhausted, or even fatigued, after work. Although they worked, the observers did not have the impression that much subjective effort was involved. The pupillograms after work showed little change from the ones taken before work. Pupillary diameter, extent and duration of contraction, and reaction shapes did not indicate increased fatigue. In analyzing the natural

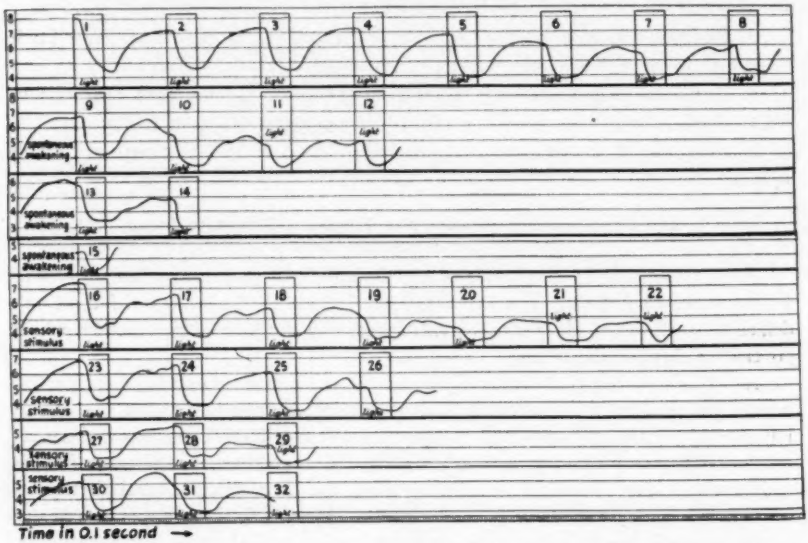

Fig. 7.—Rhythm of increasing and decreasing pupillary activity in a normal subject fatigued to the point of exhaustion by 27 hours of uninterrupted work.

The first four reactions to light are normal. As the subject gradually falls asleep, pupillary diameter and extent and duration of contraction decrease rapidly, while the various fatigue shapes of the reaction to light—V-, W-, and tonohaptic shapes—are observed.

This decline is rhythmically interrupted by spontaneous efforts of the subject to remain awake (line *2*, *3*, and *4*). Each successive restitution is less complete and of shorter duration than the previous one.

When spontaneous awakening impulses subside and the subject actually falls asleep (fifteenth reaction), the stimuli are replaced by mild sensory stimuli (blowing into the face of the subject, line *5*, *6*, *7*, and *8*). When the sensory stimuli become ineffective, the subject falls asleep (thirty-second reaction).

rhythm of fatigue and restitution, it was found that the frequency of oscillations had slightly increased, indicating a slight increase of fatigability. This increase amounted to about 10%.

B. The Subject with Central Sympathetic Irritation (Type 2) Before and After Work.—The pupillogram before work shows that fatigue is delayed and fatigability

diminished. The natural rhythm of fatigue and restitution remains unchanged through long series of stimuli and appears shallow as compared with that of subjects of other types. After work, there is hardly any change in the frequency and extent of the oscillations of fatigue and restitution. However, the pupillary reactions, which had been slightly inhibited before work, are often even better after work, since the sympathetic irritation present in persons of this type is counteracted by the reduction of the sympathetic tonus due to general fatigue.

C. The Subject with Central Sympathetic Weakness Before and After Work.—The subject of this type already shows an increased fatigability before work, when tonohaptic reactions develop quickly under the influence of reiterated light stimuli and when the oscillations composing the natural rhythm of fatigue and restitution are more frequent and extensive than those found in the normal person.

The subjects of this type expended more effort during work and reported feeling tired after—and sometimes even during—work. The pupillograms after work showed faster deterioration of the reflex to light under the influence of reiterated light stimuli and a marked increase of frequency and extent of the oscillations composing the natural rhythm of fatigue and restitution. This means further marked increase of the previously already increased fatigability.

D. The Subject with Central Sympathetic Irritative Weakness Before and After Work.—Subjects of this type have large pupils, with slight inhibition of the early reactions to light stimuli of a series, followed by a rapid loss of pupillary size and function, with premature development of tonohaptic reflex shapes. Although fatigability is not as great as in persons with sympathetic weakness, it is greater than in persons of the syntonic type.

COMMENT

The normal reflex to light is integrated at different levels of the nervous system; at each level factors are added which contribute to the final shape of the normal pupillary reflex to light. The absence of any single factor, normally integrated at a specific level, modifies the final reflex shape. The main levels of integration of the pupillary reflex to light known at this time are as follows:

1. The afferent pathways. If they are interrupted, no reflex comes into appearance; if they are damaged by partial lesions, the third nerve nucleus is stimulated at lower intensity, and reflex shapes appear which are identical with those produced either by low intensity light stimuli in unimpaired afferent pathways or by partial lesions of the third nerve nucleus.
2. The pretectal area.
3. The third nerve nucleus.
4. The ciliary ganglion.

All lesions on these four levels result in reflex shapes which have the common characteristics of parasympathetic damage: The contraction and redilation are sluggish and inextensive; the latency period preceding contraction is prolonged, and the C- and D-waves of the differential pupillogram are low and delayed, i. e., shifted to the right on the time axis. The shape of the reflex to light is further determined on the various levels of sympathetic integration:

1. Area 8 of the cortex and its connection through the hypothalamus, the sympathetic chain, and the peripheral sympathetic system. Interruption at this level or in its connections with the iris means miosis of the pupil, slight increase in the

extent of contraction, increased height of the contraction speed (C-wave), and shifting of the differential pupillogram to the left on the time axis.

2. Posterior hypothalamus, by means of its connections with the third nerve nucleus. Damage at this level leads to tonohaptic reactions in case the lesions are nonirritative. In cases in which the lesions are irritative, they lead to V- and W-shapes. The site of the irritation is not necessarily the hypothalamus itself; the stimulation due to irritation may be transmitted from other locations within the central sympathetic pathways, for instance, Area 8.

According to the law of analogy,[2] the same reflex shapes which appear permanently as the expression of permanent lesions at the different levels of integration may appear as transitory and reversible symptoms in the course of physiological fatigue, by which the normal autonomic regulation is disintegrated in a certain sequence. This sequence was stated in the general law of disintegration of central autonomic regulatory mechanisms; the law indicates that the cortical level is weakened, and its influence caused to disappear, prior to the subcortical level and that sympathetic reflex activity vanishes prior to the parasympathetic reflex activity. A certain sequence of reflex shapes is coordinated with these central processes: Increased contraction speed, with shifting to the left of the differential curve, is followed by W-shapes, V-shapes, tonohaptic reactions, shapes of delayed and inextensive reactions, and so on.

In normal persons, certain groups exist in which, under the influence of repeated light stimuli, one or the other of the fatigue shapes described appears prematurely. The experiments led to the detection of at least four such types:

(*a*) A syntonic type of autonomic regulation, in which the sympathetic-parasympathetic equilibrium is well balanced, the sequence of fatigue shapes corresponds to the statements of the general law, and the rate of fatigue is not increased.

(*b*) A type of central sympathetic irritability in which, as compared with the first type, W- and V-shapes of reaction occur prematurely.

(*c*) A type of central sympathetic weakness in which, as compared with the first type, tonohaptic reaction shapes develop prematurely.

(*d*) A type of central sympathetic irritative weakness in which, as compared with the first type, W- and V-shapes of reaction occur prematurely, as in Type 2, and are prematurely replaced by tonohaptic reaction shapes, as in Type 3.

It seems as though these types are related to personality or behavior types. This important question, however—and particularly the other, equally important, one of possible relations between these types and the development of neuroses—need further investigation; they are beyond the scope of these studies.

Close relations exist between the four types described and the rate of disintegration of autonomic regulatory mechanisms by fatigue. From a theoretical standpoint, it could be assumed that the first, syntonic, type exclusively was normal. However, about 75% of all human beings who feel well, and act and work as though they were healthy, do not belong to this type. "Normalcy" defined in a way which excludes 75% of all persons who feel well and act as healthy persons would lose its sense and its practical applicability. "Normalcy" as a sum of biological characteristics has its variability, its average, and its extreme variations, just as has each individual biological quality. In this sense, all four types must be considered as "normal," some of them possibly as extreme variations. The limits between extreme but normal variations and pathological variations may sometimes be questions of

quantity. In normal persons, all fatigue shapes described appear in the course of longer fatigue series; they should not, however, occur in the first few reactions. If they appear prematurely, a functional weakness or irritation of the sympathetic centers is present. If they appear regularly in the first reaction to light, an organic abnormality exists.

As is frequently emphasized, fatigue and defatigue are concerned with a shift in the sympathetic-parasympathetic relationship. The first symptom of disintegration by fatigue is weakness of the sympathetic component. Therefore, preexisting weakness of the sympathetic factor of autonomic reflex activity is, physiologically, identical with initial fatigue. On the other hand, a permanent condition of irritation, either physical or mental, by which the sympathetic system is stimulated and the sympathetic-parasympathetic equilibrium chronically shifted in favor of the sympathetic system, results in delay in the occurrence of symptoms of natural fatigue. Under pathological circumstances, preexisting sympathetic weakness was frequently found in patients seemingly cured of postencephalitis; in normal conditions it was found in sensitive, timid, anxious persons with a tendency toward depressive reactions and feelings of insufficiency. Central sympathetic irritation resulting in chronic stimulation was frequently found in normal persons with a hypomanic temperament.

Constitutional types of general parasympathetic irritation or parasympathetic weakness were not observed. This is understandable. Central sympathetic impulses radiate all over the body (Cannon); their influence reaches as far as the sympathetic system itself and therefore comprises the state and function of all tissues. In contrast, central parasympathetic impulses do not radiate; their influence is limited to one single reflex arc. Therefore, central parasympathetic irritation in relation to the reflex to light means a contracted and more or less immobile pupil, no more and no less. It has no influence on other parasympathetic reflexes. Central parasympathetic weakness means a dilated and more or less immobile pupil, but this also has no effect on other parasympathetic reflexes. On the other hand, disturbances of other parasympathetic reflex arcs, for instance, those concerned with the heart or the intestine, do not affect the pupillary reaction to light.[9] In other words, central parasympathetic lesions have the clinical significance of a localized condition; central sympathetic lesions have the major significance of a generalized condition.

Low intensity stimulation of the pupil results in reactions identical with those found under standard light stimulation in cases of damage to the third nerve. This is understandable; reaction shapes on low intensity stimulation are due to mild stimulation of the third nerve nucleus. They are inextensive and slow from the beginning, show an increased latency period, and, in the differential curve, present a slow increase and a low peak of contraction speed.

The stronger the light stimulus, the more sustained is the contraction, leading to a more extensive total reflex. The same is true of redilation, which is faster and more extensive as the stimulus grows stronger. At low intensity stimulation redilation takes place prematurely but lacks the speed and duration seen in high intensity stimulation; a wide-angle V-shape is thereby produced, similar to reaction shapes with high intensity stimulation in a condition of advanced fatigue.

9. See the controversial opinions of Alfred Schweitzer (Die Irradiation autonomer Reflexe, Basel, S. Karger, 1937).

The seemingly paradoxical condition occurs, so that upon low intensity stimulation autonomic nervous activity fatigues faster than on high intensity stimulation.

The rate at which fatigue symptoms develop in series of reactions to high intensity light stimuli may, in the same subject, differ from the rate shown in series of reactions to low intensity stimuli.

(*a*) In cases of syntonic reaction (Type 1), the divergence between the reaction to low intensity stimulation and the reaction to high intensity stimulation, so far as fatigability is concerned, is comparatively insignificant.

(*b*) In cases of functional sympathetic irritation (Type 2), fatigue symptoms appear much faster in reactions to low intensity stimuli than in reactions to high intensity stimuli. In these cases, a seemingly paradoxical condition exists, so that on low intensity stimulation autonomic nervous activity fatigues faster than on high intensity stimulation.

(*c*) In cases of functional sympathetic weakness (Type 3), reactions to low intensity stimuli fatigue less quickly than reactions to high intensity stimuli.

These facts are easily explained. It was frequently emphasized that in the shifting dynamic sympathetic-parasympathetic equilibrium one "optimal" relationship exists, in which a standard light stimulus of average intensity produces a maximal reflex response. This optimum is—under standard conditions and in the absence of excitement—present in the first type. In cases of functional sympathetic irritation (Type 2) the sympathetic-parasympathetic balance is shifted to a point above the optimum; in cases of functional sympathetic weakness (Type 3) it is shifted below the optimum.

In cases of sympathetic weakness (Type 3), strong light stimulation contracts the pupil easily, thus producing an extensive reflex. The equilibrium is thereby shifted far away from its optimum toward the parasympathetic. Since the sympathetic activity is relatively weak, a condition is created which corresponds to one of fatigue; accordingly, fatigability is increased. In cases of sympathetic weakness (Type 3), low intensity stimuli may not be able—for lack of power—to shift the balance definitely away from the optimum. The fatigability which was found to be high when high intensity stimuli were applied is low under the influence of low intensity stimuli when an equilibrium that is based on two weak antagonists exists and is maintained.

In cases of sympathetic irritation (Type 2), strong light stimuli shift the sympathetic-parasympathetic equilibrium toward an optimum; thereby the rate of fatigue is diminished. Low intensity light stimuli lack this power. Therefore, in cases of Type 2 the reactions fatigue faster to low intensity stimuli than to high intensity stimuli.

In the experiences of daily life analogous observations can be made. One group of persons exists who fatigue at an almost equal rate when doing light work or hard work. A second group is highly fatigued and bored by light work, but is animated and relatively indefatigable with hard work; and a third group is more easily fatigued by hard work and less fatigued by light work. These statements, of course, are correct for average, and not for extreme, i. e., pathological, conditions or extreme degrees of work.

In cases of sympathetic weakness (Type 3), additional permanent parasympathetic stimulation, such as a high level of light adaptation—which is present, for instance, if the experiments are not performed in a dark room, but are carried out

in an illuminated room—tends to shift the sympathetic-parasympathetic balance farther away from the optimum. In cases of sympathetic irritation, the same condition shifts the balance toward the optimum. General fatigability, therefore, is increased in the former case and decreased in the latter.

According to the "special law of fatigue and restitution,[1b]" which controls the stages of increasing fatigue, it must be assumed that all fatigue processes go on in a wavelike fashion. The linear decline of fatiguing activity is rhythmically, and more or less regularly, interrupted by periods of slight recovery. This recovery is the manifestation of psychosensory restitution mechanisms, activated by psychosensory stimuli which result from sensations produced by the fatigue process itself. Each of those rhythmically appearing waves of increment and decrement of function includes a sequence of fatigue shapes.

The rhythm is more pronounced as general fatigue advances, and it is most pronounced when the subject is about to fall asleep. Increasing fatigue sensations become strong and conscious at any advanced stage of fatigue and produce, periodically, conscious efforts to stay awake. These efforts finally determine the rhythm, since they coincide or interfere with the cesuras of the previously unconscious rhythm. As extreme fatigue nears exhaustion and the subject approaches the moment of falling asleep, the intervals between the cesuras, i. e., the waves, become shorter and shorter until, finally, the person falls asleep. The last reaction to light before the subject falls asleep, when the pupil is already small, generally shows a tonohaptic reaction shape. It indicates that sympathetic activity has almost come to an end. At this moment, when spontaneous awakening impulses are no longer active, outside stimuli are sometimes still able to substitute for them, until they, too, lose their effectiveness (Fig. 7).

The duration of the waves within the natural rhythm of fatigue and restitution in a subject and the rate at which the various shapes of mild or advanced fatigue appear within each wave are a measure of fatigability of the subject, while the fatigue shape of an individual light reflex is a measure of the degree of fatigue present at a given moment.

Both fatigue and fatigability of autonomic reflex activity, as represented by the pupillary reflex to light, are higher after work than before work; their development is closely related to the four types of sympathetic-parasympathetic equilibrium of the controlling mechanisms.

Well-balanced persons of the syntonic (first) type do not feel fatigued or exhausted after the strain of an average eight-hour working day. The natural rhythm of fatigue and restitution showed only a slight increase of frequency, amounting to an average of 10%.

Persons with functional central sympathetic irritation (Type 2) showed the natural rhythm of fatigue and restitution to be unchanged through long series of light stimuli; the rhythm appeared rather shallow as compared with that of other types. After work there was hardly any change in the rhythm. Frequently, the pupillary reactions which, owing to sympathetic irritation, were slightly inhibited before work appeared to have lost the inhibition after work. Work in these cases had a relaxing effect, since the sympathetic-parasympathetic equilibrium was shifted from sympathetic predominance toward the optimum.

Subjects of the third type, characterized by functional central sympathetic weakness, showed increased fatigability of the pupillary reflex to light even before work.

Tonohaptic reactions came into appearance at an early stage of fatigue under the influence of reiterated light stimuli. The rhythm of fatigue and restitution showed higher waves of greater frequency than in the first and second types. During work, these persons expended more effort and reported more sensations of fatigue than did the persons representing types 1 and 2. After work, faster deterioration of the reflex to light was observed under the influence of reiterated stimuli, while frequency and extent of the individual waves of fatigue and restitution had increased; i. e., fatigue and fatigability had advanced further. However, low intensity stimuli, in contrast to Types 1 and 2, caused the autonomic regulatory mechanisms to disintegrate at a slower rate than high intensity stimuli.

In Type 4, with central sympathetic irritative weakness, the first of a series of light reactions showed predominantly the symptoms of sympathetic irritation but were followed by the premature development of tonohaptic reflex shapes. Fatigability and fatigue after work were greater than in normal persons, but not as great as in subjects with central sympathetic weakness.

SUMMARY AND CONCLUSIONS

1. Among healthy subjects whose first response, in a series of reflexes to reiterated light stimuli, is within normal limits, four types can be distinguished in which, under the influence of fatiguing processes, the sympathetic-parasympathetic equilibrium is characteristically shifted.

Type 1: A syntonic type of autonomic regulation, in which the sympathetic-parasympathetic equilibrium is well balanced, the sequence of fatigue shapes corresponds to the statements of the general law, and the rate of fatigue is not increased.

Type 2: A type of relative central sympathetic irritability in which, as compared with the first type, W- and V-shapes of reaction occur prematurely.

Type 3: A type of relative central sympathetic weakness in which, as compared with the first type, tonohaptic reaction shapes occur prematurely.

Type 4: A type of central sympathetic irritative weakness in which, as compared with the first type, W- and V-shapes occur prematurely (as in Type 2) and are prematurely replaced by tonohaptic reactions (as in Type 3).

2. Types 2, 3 and 4 are manifestations of relative functional weakness or irritation of sympathetic centers of control. They are within the limits of normality and are distinguished from pathological cases by the fact (*a*) that in a series of consecutive reactions they show a normal first response to light, and (*b*) that the prematurely occurring fatigue shapes are transitory and reversible.

3. Close relations exist between the type of autonomic equilibrium and the rate of disintegration of autonomic regulatory mechanisms by fatigue (fatigability). As compared with the well-balanced, syntonic (Type 1) autonomic equilibrium, it was found that the types under standard conditions showed the following characteristics:

(*a*) The type of central sympathetic irritation (Type 2) shows delay of fatigue symptoms. This is explained by the fact that the sympathetic-parasympathetic equilibrium is chronically shifted in favor of the sympathetic; the weakening effect on the sympathetic characteristic of the first stages of fatigue is thereby neutralized for some time.

(*b*) The type of central sympathetic weakness (Type 3) shows fatigue symptoms appearing prematurely; this is explained by the fact that the sympathetic-para-

sympathetic equilibrium is chronically shifted in disfavor of the sympathetic; the weakening effect on the sympathetic system characteristic of the first stages of fatigue is added to the previously existing weakness.

(*c*) The type of central irritative sympathetic weakness shows fatigue symptoms to appear faster than in Types 1 and 2, but not as fast as in Type 3.

4. (*a*) The rate at which fatigue symptoms develop in response to series of high and of low intensity stimuli in the same person is about equal in the well-balanced, syntonic type (Type 1).

(*b*) In cases of functional sympathetic irritation (Type 2), fatigue symptoms appear faster in low intensity reactions than in high intensity reactions (seemingly paradoxical behavior).

(*c*) In cases of functional sympathetic weakness (Type 3), reactions to low intensity stimuli fatigue less quickly than reactions to high intensity stimuli.

These observations are explained on the general principle that parasympathetic stimuli of high intensity are able to shift the sympathetic-parasympathetic equilibrium as described in 3 of this section, while low intensity light stimuli lack this power. Therefore, in cases of Type 3, a well-balanced equilibrium between two weak antagonists exists and favors reflex activity, a condition which is not so in cases of Type 2, in which the stronger sympathetic stimuli inhibit reactions in response to weak parasympathetic stimuli.

5. General fatigue, as produced by an average eight-hour working day, has different effects on the different types.

(*a*) The well-balanced, syntonic type (Type 1): Little effect on fatigue and fatigability of the central autonomic mechanisms of control was observed. This shows that the fatiguing effect of an average eight-hour working day was not great enough to produce any disbalancement to an advanced stage of fatigue.

(*b*) The type of central sympathetic irritation (Type 2): Little effect on fatigability was seen. The autonomic reflex activity (reflex to light) was frequently improved after work. This was explained as the weakening effect of fatiguing work on the previously chronically stimulated sympathetic which, before work, had produced a slight inhibition of autonomic reflex activity.

(*c*) The type of central sympathetic weakness (Type 3): Fatigability was increased after work. In these cases, the fatiguing effect of an average eight-hour working day was great enough to cause disbalancement of central autonomic control.

(*d*) The type of central sympathetic irritative weakness (Type 4): Fatigability and fatigue after work were increased more than in Types 1 and 2, but less than in Type 3.

6. Types of generalized parasympathetic irritation or weakness were not observed. Parasympathetic irritation or weakness observed in the pupillary reflex to light has the clinical significance of a localized condition within the one reflex arc. Central sympathetic weakness or irritation, however, has the major significance of a generalized condition.

The more detailed discussion of the significance of the types described, for the psychosomatic structure of the normal or the neurotic personality, is beyond the scope of this paper.

NEUROLOGICAL CHANGES IN ANTERIOR POLIOMYELITIS AND THEIR IMPLICATIONS IN TREATMENT

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THE TREATMENT of the motor aspects of acute and subacute anterior poliomyelitis has changed strikingly within the past 10 yr. Present modes of therapy place stress on maintenance of muscle length by range-of-motion and stretching exercises. These techniques are in direct contrast with the traditional routine of immobilizing affected structures in positions designed to prevent chronic deformities due to paresis.

Although Sister Kenny's principles of therapy were largely responsible for the present emphasis on early physical therapy and the discarding of immobilization, they are by no means new. Lovett,[1] in 1916, clearly advocated muscle training as an integral part of treatment. However, Townsend,[2] in the same year, and Kendall and Kendall,[3] in 1938, enthusiastically endorsed long-term bed rest and fixation of involved extremities. Lovett's principles seemed in less vogue than the latter up to the present decade, when Sister Kenny's advent and highly publicized preachments in part reestablished them.

The Kenny system of therapy centers attention upon the outstanding muscle syndromes: combinations of motor weakness, shortening of muscles, and diminution in motor efficiency. Unfortunately, such therapy, sound in clinical application, is tied to a kite tail of extremely tenuous hypothesis as to the pathologic mechanisms underlying the clinical phenomena of poliomyelitis. It was to be expected that a physiologically naïve but intelligent observer, such as Sister Kenny, should recognize the clinical highlights but misinterpret their significance.

After 1940, impressed by the usefulness of her mode of treatment, a great many physicians adopted her techniques. This is perhaps an example of creditable elasticity on the part of members of the medical profession, and the wisdom of their choice is shown by the improved clinical results.

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1. Lovett, R. W.: A Plan of Treatment in Infantile Paralysis, J. A. M. A. **67**:421 (Aug. 5) 1916.

2. Cited by Stern, W. G., in discussion on Lovett.[1]

3. Kendall, H. O., and Kendall, F. P.: Care During the Recovery Period in Paralytic Poliomyelitis, Public Health Bulletin No. 242, United States Treasury Department, United States Public Health Service, 1938.

What is not equally clear is why the Kenny theories of pathological mechanisms became popular in the medical community. There are many possible reasons for this rather astonishing defection to gross empiricism. Perhaps chief among them is the fact that neurologists seemed largely to have lost interest in poliomyelitis, and consequently its management fell to the physiatrist and the orthopedist. The former tended to share in Sister Kenny's preoccupation with the muscles, and the latter waited patiently for the stage of definitive operative therapy. In consequence, there was very little neurological investigation or neurophysiological interpretation of the clinical signs of the disease. Real danger lay in the acceptance of the ritualistic patterns of thinking and management based on Kenny concepts.

The pillar of the Kenny theory is "muscle spasm." It is indicated as the primary pathological mechanism in the disease and the cause of all the deleterious sequelae. Other important mechanisms, according to Kenny, include "mental alienation" and "incoordination." "Paralysis due to nerve cell death occurs but is not a common condition. Most supposed weakness is due to untreated spasm."[4] The chief object of treatment lies in the dissipation of "muscle spasm" by hot foments. These must be applied at regular intervals according to a rigid formula. Any deviation from the proper temperature, degree of moisture, kind of packing material, or mode of application is considered to have grave and untoward effects upon the end results. The fact that Kenny doctrines and their clinical interpretation have taken a firm grip on the medical thinking of today is documented by the recent medical literature.

According to one author,[4] the Kenny therapy consists in eliciting the presence of muscle spasm and combating it with hot foments. After the spasm is reduced by the hot packs, exercises are carried out to prevent the appearance of "alienation" and "incoordination." Incidentally, the weight and fixation of the packs yield the same relief to motion pain as that previously afforded by plaster cases.

Many millions of dollars have been spent on the treatment of "muscle spasm" in poliomyelitis. It is of great interest to evaluate its significance in the disease and its place in treatment. The first thing to become apparent to the neurological observer is that "muscle spasm" is a nonspecific term covering a large number of differing entities. The term is not used in keeping with its neurological connotation. Clinical neurological examination reveals the following signs and symptoms interpreted as evidence of "muscle spasm":

1. Meningismus
2. Abnormal postural reflexes
3. Pain
   (*a*) Radicular
   (*b*) Skin hyperesthesia
   (*c*) Muscle soreness
4. Protective splinting
5. Late "stiffness" or loss of muscle elasticity
6. Exaggerated stretch reflex

All these entities are grouped under the designation of "muscle spasm," and their proper management (in the Kenny system) lies in the continuing application of hot foments. Such applications are not uncommonly continued into the ninth or 10th mo. of the disease, still combating "muscle spasm."

4. Pohl, J. F., and Kenny, E.: The Kenny Concept of Infantile Paralysis and Its Treatment, Minneapolis, The Bruce Publishing Company, 1943.

Since the Kenny concepts and their interpretation have allowed a great many misconceptions to arise, it is of interest to attempt to correlate the pathological changes with the clinical manifestations of the disease as they make their appearance. Only in such a way can rational treatment be defined.

The primary fact, which has often been lost sight of (and as often reiterated), is the widespread nature of involvement of the nervous system by the viruses of poliomyelitis.[5] Pathological studies reveal inflammatory and destructive lesions in the meninges, spinal cord, brain stem, cortex, sensory ganglia, and, at times, nerve roots. Actual involvement of the muscle or of the intrafusal fibers of the motor nerve and its end plate have been described. While the latter areas are suspect and there is ancillary evidence of their implication, no conclusive histological studies have been made.

Analysis of lower-animal and human material reveals a statistically high incidence of involvement of vestibular centers and pathways, as well as of the bulbar reticular substance. The deeply ingrained impression of poliomyelitis as a disease of the motor horn cells is based largely on the fact that the residual effects are a reflection of irreversible damage to these areas. Also, the striking "safety factor" in the functioning of the brain-stem center obscures the changes in that region.

With this gross review of the nature of involvement in poliomyelitis, the clinical signs may be reevaluated. The most striking early sign of acute poliomyelitis is the position adopted by the patient. At first glance, it is reminiscent of pure meningismus, but one is soon struck by marked variations from the latter. In true meningismus, an attempt is made to shorten the neuraxis and splint it in that position to prevent noxious stretching of involved neural elements—thus opisthotonos. Head retraction is marked and cannot easily be reduced. In contrast, in poliomyelitis these signs vary markedly with the position in which the patient is placed and seem strikingly related to postural reflex patterns. Since there is early involvement of vestibular and bulbar reticular nuclei, one may surmise that the clinical picture in part represents the release of postural mechanisms. These, in turn, are engrafted upon the meningismus, which is secondary to the inflammatory process.

Within a short time, the picture of meningismus and increased postural "tone" passes into a more localized pattern, with dissolution of the general signs but with residual manifestations in the zone of specific involvement. This period may be correlated with a reduction in the severity of the process in the brain stem. Residua of the meningismus remain. The back is stiff, and the limbs resist motion which would put traction on the neuraxis. At this point, there is an immense variability in the clinical picture, depending upon the permutations and combinations of structural involvement in the nervous system. If there are pronounced pleocytosis and meningeal infiltration without much involvement of sensory tracts or sensory ganglia, limitation of motion will seem mysterious and represent pure protective

5. Bodian, D.: Poliomyelitis: Pathologic Anatomy, in Poliomyelitis, papers and discussions presented at the First International Poliomyelitis Conference, Philadelphia, J. B. Lippincott Company, pp. 62-84, 1949. Sabin, A. B., and Ward, R.: The Natural History of Human Poliomyelitis: I. Distribution of Virus in Nervous and Non-Nervous Tissues, J. Exper. Med. **73**:771 (June) 1941.

splinting as a moiety of the meningismus or a fragment of an opisthotonic pattern. If, however, there is reactive cellular infiltration of the sensory ganglia, there may be pain at rest, hyperesthesia, or merely pain on motion or stretching, as in the Lasègue test. Vasomotor changes may accompany involvement of the sensory ganglia or represent implication of autonomic centers and pathways. Rarely, true muscle spasm may be present as an accompaniment of severe spontaneous pain. In the series studied, and in others reported,[6] the latter was, however, uncommonly found.

Exaggerated stretch response may occur in all phases of the disease. In the first, it may be a transient part of a generally heightened reflex excitability, or increased postural "tone." Later, it may appear secondary to potentiation of the segmental reflex arc due to severe pain. In the more chronic phase of the disease, it may be seen in the presence of partially contracted paretic muscles. Here it is probably a more local myotatic response and is seen equally well in rheumatoid arthritis and other syndromes characterized by muscular pain, limitation of motion, and muscle shortening.

As the disease progresses and motor weakness becomes fixed, these transient phenomena are replaced by intrinsic muscular changes, with stiffness, shortening, and, presumably, fibrosis supervening. Careful attention to maintenance of length and range of motion, with the accruing dividends of improved blood supply and prevention of loss of muscle volume, may prevent or abort some of these later changes. The important point to be made is that the changes are of a different pathological nature than those which preceded them.

To recapitulate, there are initially meningismus and an increase in muscle tone secondary to disruption of central nervous mechanisms, with release of primitive postural patterns. The general response then recedes, while the local picture becomes more prominent but is still a reflection of much more than simple anterior horn cell disease. The third phase then represents the gradual disappearance of all clinical signs of central reaction other than specific irreversible changes, and the superimposition upon these of the chronic changes in the muscles as a sequel to degeneration of the ventral horn cells.

Any present analysis of the subacute "stiffness" and shortening is unsatisfactory. Muscle biopsies are difficult to interpret, and investigation of this phase of the process leaves much to be desired. The recent findings of Hodes,[7] if corroborated, are strongly suggestive of changes at the myoneural junction as part of the disease process. It will be remembered that Carey and associates [8] described motor-end-plate changes repeatedly in his special histological studies of muscles in poliomyelitis. On the other hand, it is not inconceivable that involvement of the intrafusal neural fibers, with subsequent changes in proliferation of effector substance (as in botulinus

6. Pollock, L. J., and others: Absence of Spasm During the Onset of Paralysis in Acute Anterior Poliomyelitis, Tr. Am. Neurol. A. **72**:57, 1947.

7. Hodes, R.: Electromyographic Study of Defects of Neuromuscular Transmission in Human Poliomyelitis, Arch. Neurol. & Psychiat. **60**:457 (Nov.) 1948.

8. Carey, E. J.; Lassopust, L. C.; Zeit, W., and Haushalter, E.: Anatomic Changes of Motor Nerve Endings in Human Muscles in Early Poliomyelitis, J. Neuropath. & Exper. Neurol. **3**:121 (April) 1944.

poisoning)[9] may play a part. At any rate, no adequate explanation for the changes has been brought forth. As one would expect, treatment is as inefficient as it is nonspecific.

The greatest value of an attempt to correlate clinical signs with neuropathological changes lies in its implications in treatment. Obviously, the hot pack cannot be expected seriously to alter the aforementioned march of neuropathological changes; and, indeed, it does not. Likewise, muscle relaxants, local anesthetics, or sympatholytic agents cannot logically be put forth as therapeutic measures to be applied haphazardly in the time table of disease progression. To be of value, any agent must be utilized during the period of the evolution of the morbid changes in the nervous system and muscles when it has a logical application. To attempt to increase range of motion when the check to range of motion represents protective splinting of neural elements may merely add noxious stimuli. On the other hand, if restriction of motion is purely of local muscular origin, its relief may have a more rational clinical basis.

In order to determine the latter point graphically, a group of 10 patients with marked limitation of motion of the lower extremity were given intravenous injections of mephenesin (myanesin®) in critically relaxant doses.[10] At no time, in spite of complete reduction of muscle tension; was more than a few degrees of additional motion gained. The end point was always determined by the pain which occurred when neural elements were placed on stretch. It is apparent that in this stage the use of muscle relaxants to increase range of motion would be illogical. Whether or not they would make range of motion easier within the limit of evocation of pain is a different question, and an unanswered one.

Many clinical problems in the treatment of poliomyelitis remain to be analyzed. The exact place of moist heat, whether it can be effectively replaced by analgesics or muscle relaxants, and the optimal time for institution of active physical therapy are all questions with only empirical answers at this time.

SUMMARY

The Kenny treatment of acute and subacute anterior poliomyelitis rests in part on unsound physiological concepts. This state is in part due to the neglect of the disease by the neurologist and the misinterpretation of clinical signs by less adroit students of the nervous system. The concept of treatment as being largely a problem in combating muscle spasm is erroneous. The term "muscle spasm" as used in describing clinical patterns in poliomyelitis bears no resemblance to the term as understood by the neurologist. The clinical changes in poliomyelitis represent progressive manifestations of involvement of various parts of the central nervous system and vary strikingly from case to case, depending on the areas affected and the severity of the lesions. Three phases of neurological changes and their implication are described. The fallacy of attempting to treat all phases by a single therapeutic agent, thermal or pharmacological, is discussed. A clinical experiment designed to demonstrate the latter point is described.

9. Burgen, A. S. V.; Dickens, F., and Zatman, L. J.: The Action of Botulinum Toxin on the Neuro-Muscular Junction, J. Physiol. **109**:10 (Aug.) 1949. Ambache, N.: The Peripheral Action of Cl. Botulinum Toxin, ibid. **108**:127 (March) 1949.

10. Schlesinger, E. B.; Drew, A. L., and Wood, B.: Applications of Myanesin in Neurology, Tr. Am. Neurol. A. **73**:94-100, 1948.

CONCLUSIONS

1. The Kenny method of therapy is sound in respect to its goal of preventing deformity, shortening of muscles, and loss of muscle volume by range-of-motion exercises.

2. The underlying concepts of Kenny doctrine are unsound physiologically and lead to ritualistic and empirical management of the disease process.

3. Members of the medical profession have been quick to improve traditional techniques by adopting some of Kenny's methods, but lamentably uncritical of her concepts.

4. The Kenny and generally medically accepted concepts of "muscle spasm" in poliomyelitis are probably erroneous in physiological terms.

5. "Muscle spasm" can actually be divided into large groups of pathological neural mechanisms of clinical significance.

6. The various entities which are grouped under the name of "muscle spasm" cannot be expected to respond to a single therapeutic agent.

7. Hot packs, muscle relaxants, etc., must be exhibited in proper relation to the mechanisms at play at a given point in the progress of the disease to be of value.

8. The evidence adduced discounts the value of muscle relaxants during at least one phase of the acute disease.

MYOSITIS OSSIFICANS OCCURRING IN POLIOMYELITIS

Report of a Case

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A REVIEW of the literature fails to produce a specific incident of myositis ossificans developing in a paralytic patient whose paralysis was the result of anterior poliomyelitis. Since it is well known that myositis ossificans occurs in more than 4% of patients with paraplegia from other causes,[1] it would appear that it could occur with poliomyelitic paraplegia. The case to be reported demonstrates this.

REPORT OF CASE

A 7-yr.-old white girl was admitted to the House of St. Giles the Cripple, Brooklyn, on Sept. 6, 1949, with a diagnosis of anterior poliomyelitis, with onset Aug. 13, as proved by clinical and laboratory findings. The acute illness had been treated at another hospital.

On her admission to St. Giles, it was noted that there was moderate stiffness and spasm of the neck, back, and hamstring muscles. Muscle evaluation showed that the strength of the musculature of the upper extremity was essentially normal, that of the abdominal muscles fair, that of the back fair, and that of the lower extremities zero to a trace.

Treatment consisted of routine physical therapy, which included daily application of hot packs, muscle reeducation, passive stretching of all taut muscle groups, and bed rest on a firm mattress with a footboard. Use of the hot packs was terminated after six weeks, when all muscular tenderness had subsided. Active and passive physical therapy was then continued.

By Dec. 12, four months after onset, muscle evaluation was as follows: Abdominal muscles were graded fair bilaterally; back muscles, fair; the quadratus lumborum, fair minus bilaterally. Strength in the left lower extremity was graded zero to a trace in all muscles, and that in the right lower extremity, a trace to poor in all muscles, except for good in flexor digitorum longus and fair in the gastrocnemius. Straight-leg raising to 90 degrees was possible bilaterally, with moderate pain. There was moderate atrophy bilaterally and no shortening.

On Dec. 19, 1949, three months after admission, while undergoing stretchings of the hamstring muscles, the patient sustained an oblique fracture of the right midfemoral shaft. The roentgenograms made immediately after fracture showed not only the fracture, but also deposits of amorphous calcific material in the soft tissues anterior and medial to the proximal femoral shafts (Fig. 1).

The fracture was reduced and immobilized by a plaster-of-paris double-hip spica for three months, after which the patient was allowed to be free in bed with only a footboard support. After removal of the plaster, roentgenograms revealed an advancement of the previously mentioned myositis ossificans (Fig. 2). The new bone formation extended from the region of the anterior inferior iliac spine to the anterior aspect of the greater trochanter bilaterally, being more extensive on the right.

At the time of this report, the muscle evaluation is much the same as in December, 1949. The right hip is, however, fixed in a position of 30-degrees abduction, 10-degrees flexion, and

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From the service of Mather Cleveland, M.D., and David M. Bosworth, M.D., House of St. Giles the Cripple, Brooklyn.

1. Miller, L. F., and O'Neill, C. J.: Myositis Ossificans in Paraplegics, J. Bone & Joint Surg. **31**:283 (April) 1949.

A

B

Fig. 1.—Immediate postfracture roentgenograms, showing amorphous calcific material in the soft tissues anterior and medial to the proximal femoral shafts. *A*, anteroposterior view of the pelvis; *B*, fractured right femur.

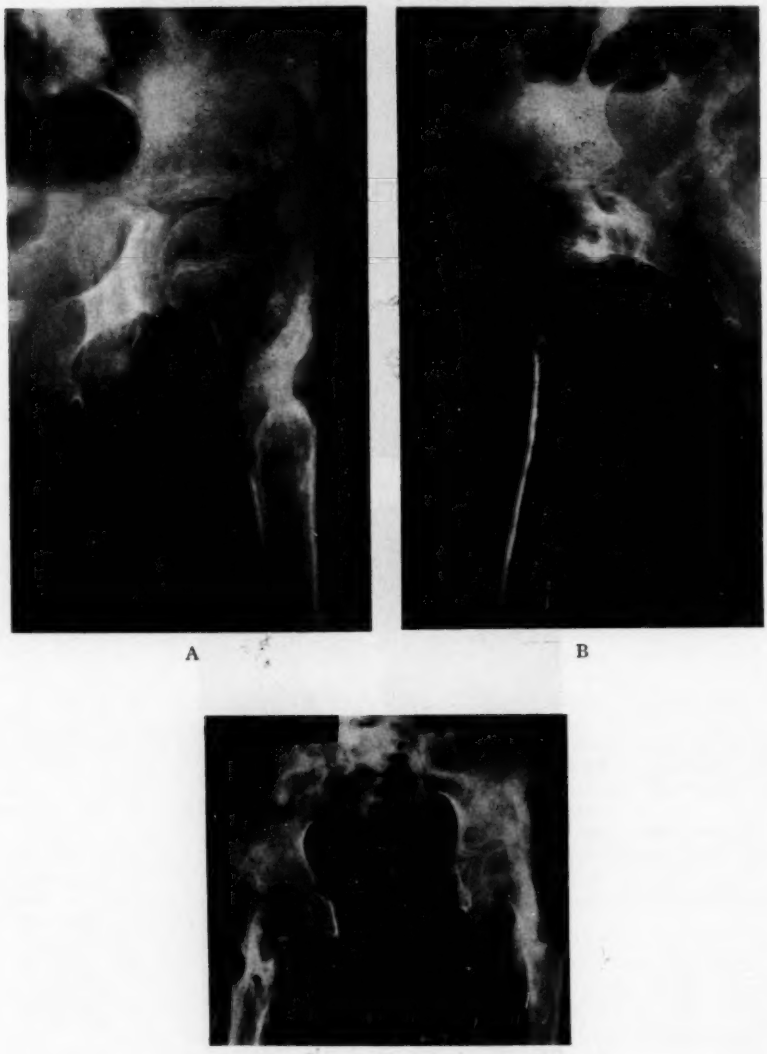

Fig. 2.—Anteroposterior and lateral roentgenograms of both hips, five months after fracture, showing consolidation of the myositic process. *A*, right lateral; *B*, anteroposterior, and *C*, left lateral view.

neutral rotation (Fig. 3). The left hip is almost fixed in a position of 20-degrees adduction, 10-degrees flexion, and neutral rotation, there being less than 5 degrees of motion in any plane. Flexion of the knees is limited to 35 degrees bilaterally. The circumference of the high and middle portions of the thigh on the right is 1 inch (2.5 cm.) greater than on the left, and the myositic process is palpable as a bony-hard, nontender, immobile ridge anterior to both hip joints, and more prominent on the right.

As is usual in cases of myositis ossificans, all laboratory data are normal, including 9.4 mg. of serum calcium and 4.2 mg. of phosphorus, per 100 cc. and 6.4 Bodansky units of alkaline phosphatase. A flat plate of the abdomen fails to show any calcium deposits in the genito-urinary tract.

Fig. 3.—Anteroposterior view of the patient supine in bed five months after fracture.

The present plan of therapy is to apply long leg braces bilaterally and to ambulate the child with a four-point gait.

COMMENT

A fracture occurred in a patient with postpoliomyelitic paralysis, but the evidence of a preexisting myositis ossificans was already present, as shown by the immediate postfracture roentgenograms. The process proceeded to ossify and to consolidate further during the period of immobilization.

The likeliest cause of the myositis ossificans was trauma from overzealous stretchings in the treatment of paralysis. The danger arising from such stretchings is emphasized.

PHANTOM LIMBS OF PATIENTS WITH SPINAL CORD INJURY

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REVIEW OF LITERATURE

THE LITERATURE is replete with information on the phantom limb of the amputee. Data are also readily available which are concerned with disturbances of the body scheme. Periphery and center have thus found attention with regard to phantom phenomena; in contrast, little is known of the phantoms which accompany an injury of the spinal cord.

Riddoch [1] and Mayer-Gross [2] are the only authors to have reported their observations on patients (and the number is relatively small) with injuries of the spinal cord. One reason for the scarcity of information may be that the survival period following trauma to the spinal cord was brief in the past. Another reason for the "apparent rarity" may be, in the words of Riddoch,[1c] that the "phantoms may exactly coincide with the real limbs."

Recent advances of management and rehabilitation in paraplegic centers [3] have made possible a study on a larger scale. Interesting information was gained from observations on patients with traumatic paraplegia combined with some other condition, e. g., amputations of various limbs or spinothalamic tractotomy. We were unable to find previous reports of either combination.

Stone [4] has reviewed comprehensively the literature concerning the phantom limb of the amputee, and only the highlights will be touched upon here. This information can be divided into three parts: (1) the painless phantom, (2) the painful phantom, and (3) the mechanism of origin of the phantom.

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Sponsored by the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the author are the result of his own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

1. Riddoch, G.: (*a*) The Reflex Functions of the Completely Divided Spinal Cord in Man, Compared with Those Associated with Less Severe Lesions, Brain **40**:617, 1917; (*b*) ibid. **41**:264, 1918; (*c*) Phantom Limbs and Body Shape, ibid. **64**:197-222, 1941.

2. Mayer-Gross, W.: Ein Fall von Phantomarm nach Plexuszerreissung, mit einigen Bemerkungen zum Problem des Phantomgliedes überhaupt, Nervenarzt **2**:65, 1929.

3. (*a*) Bors, E.: Spinal Cord Injuries, Veterans Administration Technical Bulletin TB 10—503, 1948. (*b*) Guttmann, L.: Surgical Aspects of the Treatment of Traumatic Paraplegia, J. Bone & Joint Surg. **31-B**:399-403, 1949. (*c*) Freeman, L. W.: Treatment of Paraplegia Resulting from Trauma to the Spinal Cord, J. A. M. A. **140**:949-958 (July 16) 1949; 1015-1022 (July 23) 1949; Correction, ibid. **141**:275 (Sept. 24) 1949.

4. Stone, T. T.: Phantom Limb Pain and Central Pain: Relief by Ablation of a Portion of Posterior Central Cerebral Convolution, Arch. Neurol. & Psychiat. **63**:739-748 (May) 1950.

1. The painless phantom has been described in terms of its length, size, representation of distinct parts, attachment to the stump, and color by Guéniot,[5] Mitchell,[6] Foerster,[7] Riddoch,[1c] and many others. Length and behavior of the phantom have been studied under experimental conditions—when the stump was exposed to faradization, cocainization, application of ethyl chloride, submersion in cold or warm water, weight-bearing or wearing of a prosthesis, and plastic surgical procedures.[8] Similar changes were studied during hypnosis and sympathetic procaine blocks.[9]

2. The painful phantom was first described by Ambroise Paré[10] in 1552, and numerous operations have been devised to combat it. Resection of neuromas, posterior and anterior rhizotomy, sympathetic procaine block or sympathectomy, posterior rhizotomy with sympathectomy, chordotomy, postcentral and precentral topectomy, and leucotomy have been performed.[11]

3. Understanding of the origin of the phantom was increased by two types of contributions. One was the result of studies of the cortical function by ablation and stimulation experiments[12]; the other was concerned with investigations of the body

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5. Guéniot: D'une hallucination du toucher (ou hétérotopie subjective des extrémitées) particulière à certains amputées, J. physiol. et path. gén. **4**:416, 1861.

6. Mitchell, S. W.: (*a*) Phantom Limbs, Lippincotts Mag. Pop. Lit. Science **8**:563-569, 1871; (*b*) Injuries of Nerves and Their Consequences, Philadelphia, J. B. Lippincott, 1872.

7. Foerster, O.: Über das Phantomglied, Med. Klin. **27**:497-500, 1931.

8. (*a*) Mitchell.[6a] (*b*) Souques and Poisot, cited by Stone.[4] (*c*) Adler, A., and Hoff, H.: Beitrag zur Lehre vom Phantomgliede, Monatsschr. Psychiat. u. Neurol. **76**:80-86, 1930. (*d*) Riechert, T.: Beobachtungen an einem Phantomarm, Nervenarzt **7**:566, 1934. (*e*) Jung, A.: Recherches sur la physiologie pathologique des moignons d'amputation, Progr. méd., Paris **76**:275-278, 1948. (*f*) Kallio, K. E.: Phantom Limb of Forearm Stump Cleft by Kineplastic Surgery, Acta chir. scandinav. **99**:121-132, 1949.

9. (*a*) Kallio.[8f] (*b*) Betlheim, S.: Zur Lehre vom Phantomgliede, Deutsche Ztschr. Nervenh. **90**:271-283, 1926.

10. Paré, A.: Oeuvres complètes d'Ambroise Paré, edited by J. F. Malgaigne, Paris, J. B. Baillière, 1840, Vol. 2, pp. 221-231.

11. (*a*) Foerster, O.: Der Schmerz und seine operative Bekampfung, Nova acta Leop. Carol. **3**:1-60, 1935; (*b*) footnote 7. (*c*) Leriche, R.: Les douleurs des moignons d'amputation, Presse méd. **40**:869-873, 1932; (*d*) La chirurgie de la douleur, Paris, Masson et Cie, 1937. (*e*) Livingston, W. K.: Fantom Limb Pain: A Report of 10 Cases in Which It Was Treated by Injections of Procaine Hydrochloride Near the Thoracic Sympathetic Ganglions, Arch. Surg. **37**:353-370 (Sept.) 1938; (*f*) Pain Mechanism: A Physiologic Interpretation of Causalgia and Its Related States, New York, The Macmillan Company, 1944. (*g*) Gutierrez-Mahoney, C. G.: The Treatment of Painful Phantom Limb by Removal of Postcentral Cortex, J. Neurosurg. **1**:156-162, 1944. (*h*) Horrax, G.: Experiences with Cortical Excisions for Relief of Intractable Pain in Extremities, Surgery **20**:593-602, 1946. (*i*) Echols, D. H., and Colcough, J. A.: Abolition of Painful Phantom Foot by Resection of the Sensory Cortex, J. A. M. A. **134**:1476-1477 (Aug. 23) 1947. (*j*) Puech, P.; Brousseau, A.; Brun, M., and Maurice, J.: Exerèse corticale rolandique dans un cas d'algohallucinose des amputés avec épilepsie du moignon, Ann. méd.-psychol. **106**:45-46, 1948. (*k*) Waugh, O. S.; Cameron, H. F.; Howard, J. C., and Matas, J.: Prefrontal Leucotomy for Painful Phantom Limb, Canad. M. A. J. **61**:364-367, 1949.

12. (*a*) Foerster.[11a] (*b*) Evans, J. P.: A Study of Sensory Defects Resulting from Excision of Cerebral Substance in Humans, A. Res. Nerv. & Ment. Dis., Proc. **15**:331-370, 1935. (*c*) Penfield, W., and Boldrey, E.: Somatic Motor and Sensory Representation in Cerebral Cortex of Man as Studied by Electrical Stimulation, Brain **60**:384-443, 1937. Walker, A. E.: Central Representation of Pain, A. Res. Nerv. & Ment. Dis., Proc. **23**:63-85, 1943.

scheme, or body image.[13] From these studies originated the present terminology of a surface, postural, and visual model of the body and the recognition that periphery and center form an indivisible unit in the creation of the body image. Phantom pain was linked to the surface model, and all phantom phenomena were explained by the relation of peripheral stimulation and central inhibition. Anatomic and physiologic disturbances of the body scheme were distinguished from each other when caused by central lesions, and eventually a general cerebral localization was worked out for the body scheme.

MATERIAL

The data here presented have been derived from three groups of patients: Group 1: 50 patients, who form the basis of the study; Group 2: 7 paraplegic patients with amputation, all but 2 of whom are recorded in Group 1; Group 3: 12 patients with paraplegia who have undergone anterolateral chordotomy, these patients also being included in Group 1.

Group 1.—*Fifty Patients with Segmental Lesions of the Cord.*—The interviews with the patients took place from two months to almost eight years after injury. Two or more interviews were held with 31 of the 50 patients. A total of 82 interviews were distributed as follows: Within the first year after injury, 16; one to three years after injury, 11; three to five years after injury, 19; five to six years after injury, 24; six to eight years after injury, 12. The interval between interviews averaged from 2 to 10 months, with one exception, of 25 months.

Thirty patients were in the third decade; 17, in the fourth decade; 2, in the fifth decade, and 1, in the sixth decade of life. The youngest patient was 20 and the oldest 56 years of age.

The levels of vertebral injury were distributed as follows:

Level of Injury	No. of Cases	Level of Injury	No. of Cases
Th 1-4	7	L 1	5
Th 5-8	14	L 2	2
Th 9-12	19	L 3	2
		L 4	1

The lesion was considered clinically complete at the vertebral level in 43 patients and incomplete in 7 patients. The incomplete lesions concerned the following levels: 7th thoracic, two cases; 11th thoracic, one case; 12th thoracic, two cases; 2d lumbar, one case, and 4th lumbar, one case.

The lesion in the cord was caused by bullets or shell fragments in 29 patients and by fractures in 21 patients. A record of the anatomic findings at laminectomy was available for 20 patients—6 with lesions from bullets or shell fragments and 14 with fractured vertebrae. The pathologic observations were varied.

Four categories of questions were asked: (1) those referring to the unit, shrinkage, and position of the phantom limb; (2) those referring to a detailed incidence of distinct parts of the phantom, from toe to hip joint; (3) those referring to the movements of the phantom, including the anal sphincter, and (4) those referring to a phantom of unpaired organs, such as the bladder, rectum, and penis.

RESULTS

Group 1: *Unit; Shrinkage; Position of Phantom* (Chart 1).—(*a*) Unit: All patients had a phantom. An attempt to analyze the sensations which induced the patient to feel his extremity as a whole unit, or entity, yielded the following information: The majority of the patients (37) stated that this phenomenon originated from either one or a combination of two or more of the following sensations, which

13. (*a*) Head, H., and Holmes, G.: Sensory Disturbances from Cerebral Lesions, Brain **34**:102-254, 1911. (*b*) Schilder, P.: Image and Appearance of the Human Body: Study in the Constructive Energies of the Psyche, Psyche Monographs No. 4, London, J. George Routledge and Sons, Ltd., and Kegan Paul, Trench, Trubner & Co., Ltd., 1935. (*c*) Riddoch.[1c] (*d*) Nielsen, J. M.: Agnosia, Apraxia, Aphasia: Their Value in Cerebral Localization, Ed. 2, New York, Paul B. Hoeber, Inc., 1947.

they connected with the surface of the extremity: burning, tingling, vibrating, sensation "as though asleep" or "as though waking up," numbness, and tightness. Seven patients reported that the sensation of the unit was perceived only when they attempted to move the phantom, and one patient had this impression only when he concentrated on the position of his phantom, which was rigidly straight. One patient had a sensation of "swollen flesh," and another, a sensation as though the unit were maintained by a "wire" which held the joints together. These 10 patients had sensations which they projected to the depth of the extremity rather than to the surface. Two patients had a disturbance of the unit. One reported "gaps" or "holes" between the phantoms of foot, knee, and hip, and another related that only the visual impression maintained the unit. For one patient the presence of the phantom was not determined.[14]

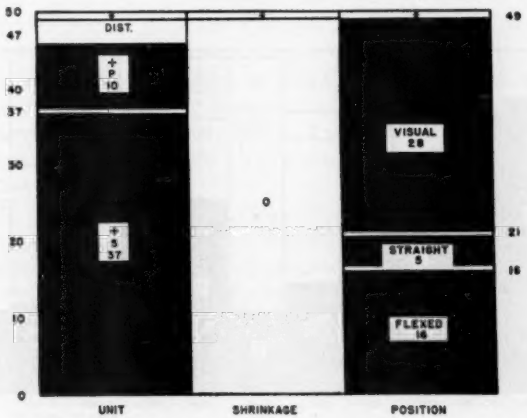

Fig. 1.—Incidence of paraplegia phantom with respect to entity, shrinkage, and position in 50 patients. $+S$ refers to surface; $+P$ to posture; *Dist.*, indicates disturbance; the asterisk, that the presence of the phantom was not determined, and the white area with *0*, absence of the phantom.

The sensation of the unit could not be correlated with the age of the patient, the level of the lesion, or the time interval between injury and interview.

(*b*) Shrinkage: This term embodies the phenomena of shortening, telescoping, and decrease in size of the phantom which are commonly observed by amputees. None of these was noted by any of the paraplegic patients in this series.

(*c*) Position: Whereas the position in which the patient "felt" his legs could be related neither to his age nor to the level of injury, it did depend in some cases upon the time interval between injury and interview. Within the first days, weeks, or sometimes months, 21 patients noted a dissociation between the position of the phantom and the actual position of the paralyzed limb. Sixteen of these felt their extremities in a flexed position at the hip joint, or knee joint, or both, or had a sensation as though their legs were "twisted," "crossed," or "blown up." Five other patients felt their legs to be straight from the very beginning. These initial impressions wore off in all cases, and eventually 49 patients felt their extremities in the

14. The patient was not questioned in this respect.

position in which they actually were at the time of the interview. For one patient the presence of the phantom was undetermined. Two patients reported that they did not "feel" their extremities at all at the time of injury, and two other patients believed that they "felt" them in the position last seen after the accident. There was one who asked the medical aid man on the battlefield, "Whose extremities are these, in such an awkward position?" not recognizing them as his own.

Detailed Incidence of Phantom (Chart 2).—(*a*) Toes: A toe phantom was present in 43 and absent in 7 patients; 33 stated that the big toe was more distinct than the other toes. Two patients had no phantom of the big toe but felt other toes. Eight patients felt all toes equally well. The position of the toes was straight in 11 and cramped or bent in 7 patients. Twenty-five did not comment. There was no correlation with the age of the patient, the level of the lesion, or the time interval since injury.

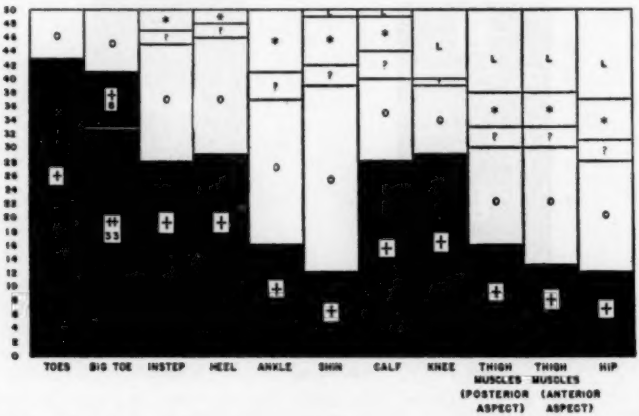

Fig. 2.—Incidence of paraplegia phantom with respect to paired structures. Black areas indicate presence, and white areas with *0*, absence of the phantom; * means that its presence was not determined; ?, that it was questionable, and *L*, that the level of the lesion ruled out evaluation.

(*b*) Instep: An instep phantom was present in 28 patients and absent in 17 patients. Two patients could not decide whether or not such a phantom appeared sporadically. For three its presence was not determined. No correlation could be established with the patient's age, the level of the lesion, or the time interval since injury.

(*c*) Heel: A heel phantom was present in 29 patients and absent in 17 patients. Two patients were undecided. For two the condition was undetermined. No correlation could be established with the patient's age, the level of the lesion, or the time interval since injury.

(*d*) Ankle: An ankle phantom was present in 16 patients and absent in 21. Four patients were undecided as to its presence. For nine patients its occurrence was undetermined. There was no correlation with age, level of the lesion, or the time element.

(*e*) Shin: A shin phantom was present in 12 patients and absent in 27 patients. For three patients its presence was undecided. In seven patients its occurrence was not determined. One case could not be included because the sensory level reached to the shin. Two patients stated that they were aware of the shin, either "owing to motion of the toe" or because the shin "separates the bone from the meat." No correlation existed with the factors of age, level of the lesion, or time interval.

(*f*) Calf: A calf phantom was present in 28 patients and absent in 12 patients. Four patients were undecided. In one case the status was not evaluated because there was some volitional motion in the calf musculature. For five patients its presence was undetermined. No correlation was demonstrable with the elements of age, level of the lesion, or time interval.

(*g*) Knee: A knee phantom was present in 29 patients and absent in 10 patients. One patient was undecided. In 10 cases, the condition could not be evaluated because afferent or efferent pathways were not completely interrupted. There was no correlation with age, level of lesion, or time interval.

(*h*) Muscles of Posterior Aspect of Thigh: A phantom was present in 16 patients and absent in 14 patients. Three patients were undecided as to its presence, and for five the condition was undetermined. Twelve patients were omitted because of some preservation of innervation. There was no correlation with age, level of lesion, or time.

(*i*) Muscles of Anterior Aspect of Thigh: A phantom was present in 13 patients and absent in 17 patients. Its presence was undecided by three patients, and was undetermined for five patients. Twelve patients were omitted from the series because of some preservation of innervation. No correlation existed with age, level of lesion, or time.

(*j*) Hip: A phantom was present in 12 patients and absent in 16 patients. Its presence was questioned by three patients and was not determined for six patients. Thirteen patients were omitted because of some preservation of innervation at the hip joint. There was no correlation with age, level of lesion, or time.

Movements of the Phantom (Chart 3).—(*a*) Toes: Voluntary motion was present in 28 patients and absent in 19 patients. One patient experienced involuntary movements; two patients were undecided as to their presence, and for one their presence was undetermined.

(*b*) Ankle: Voluntary motion was present in 10 patients and absent in 25 patients. For two patients its presence was undecided, and for 13 patients it was not determined.

(*c*) Calf: Voluntary motion was present in 20 patients and absent in 18 patients; 3 patients could not decide whether motion was occasionally present or absent. One case was not included because of some preservation of innervation of the calf. For eight patients its presence was not determined.

Ipsilateral associated movements of the thigh musculature occurred in six patients when they attempted to move the muscles of the calf. Their segmental levels of physiologic transection were the 6th thoracic, 10th to 11th thoracic (two patients), 11th thoracic, and 11th and 12th thoracic (two patients), respectively. Among them was one patient (lesion, 10th to 11th thoracic level) who stated that he could tighten his calf muscles only when he attempted it on both sides simultaneously, thus displaying the phenomenon of symmetrical associated movement in the phantom.

(*d*) Knee: Voluntary movements of the phantom were present in 14 patients and absent in 23 patients. Three patients were undecided as to its presence. Ten patients were not included because of lack of complete motor paralysis at the knee joint. Ipsilateral associated movements occurred in two patients who had complete lesions at the level of the 2d and 11th thoracic segments, respectively. The associated movement concerned the hip in one case and the thigh muscles in the other. One patient retained voluntary motion until two years after injury, when it subsided. His lesion was complete at the level of the 11th and 12th thoracic segments.

(*e*) Muscles of Posterior Aspect of Thigh: Voluntary motion was present in 13 patients and absent in 14 patients; 4 patients were undecided as to its presence, and for 7 its occurrence was not determined. Twelve patients were omitted because of lack of complete motor paralysis.

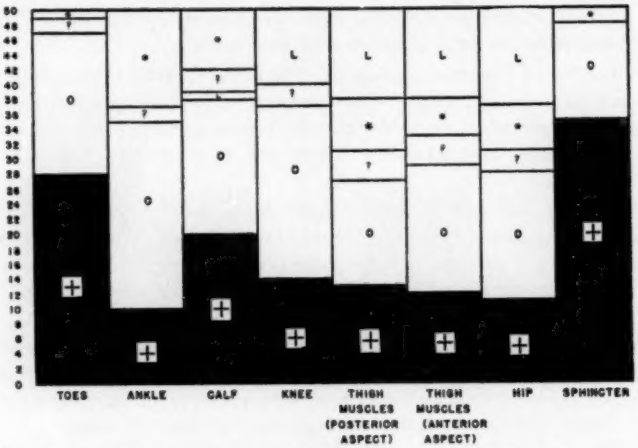

Fig. 3.—Incidence of movements of the phantom. Black areas indicate their presence, and white areas *0*, their absence; ? means that their presence was questionable, and *, that it was not determined; *L* indicates that the level of the lesion ruled out evaluation.

(*f*) Muscles of Anterior Aspect of Thigh: Voluntary movements were present in 12 patients and absent in 17 patients; 4 could not decide whether the movements were present, and for 5 their presence was not determined. In 12 cases the condition was not suitable for evaluation because of lack of complete motor paralysis. Three patients had associated movements of the calves, and one of them also had associated movements at the knee joint. Their segmental levels were at the 6th, 11th, and 11th thoracic, respectively, and they were a part of the group listed in *c* (calf).

(*g*) Hip: Voluntary movements were present in 11 patients and absent in 17 patients; 3 patients were undecided, and for 6 their presence was undetermined. Thirteen patients were omitted because of lack of complete motor paralysis. Only one patient had associated movements of the hip and knee. His lesion was complete at the 11th thoracic segment, and he was one of the patients with associated movements, listed above.

(*h*) Anal Sphincter: Phantom movements were present in 35 patients and absent in 13 patients. For two patients they were not determined.

All phantom movements were independent of the age of the patient and the level of the lesion. With the exception of a single patient, who lost voluntary motion of the knee phantom two years after injury, no correlation could be established with the time interval after injury.

4. *Phantom of Unpaired Organs* (Chart 4).—(*a*) Rectum: A phantom of the rectum was present in 11 patients and absent in 36 patients, and its presence was undecided by 1 patient. For two patients it was undetermined. Among the 11 patients, the following phantom sensations were reported: Seven patients felt a continuous distention of the rectum, although the viscus was completely empty. One patient had a continuous feeling of defecation; one had a sensation of tightness.

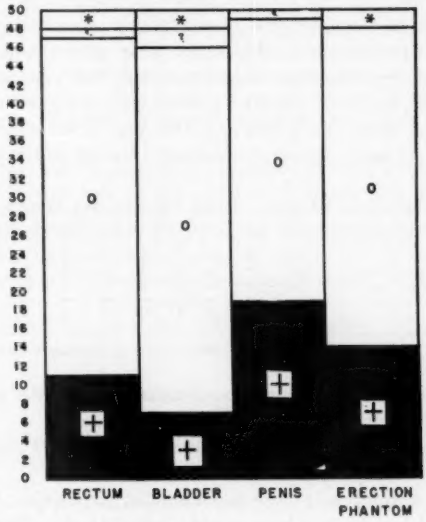

Fig. 4.—Incidence of paraplegia phantom in unpaired organs. Black areas indicate its presence; white areas with *0*, its absence; ? means that its presence was questionable, and *, that its presence was not determined.

and two had "just the sensation of having a rectum." It is possible that the patient with "tightness" meant the sphincter rather than the rectum, inasmuch as his statements failed to record sphincter movements. Of the two patients with "just" a rectum phantom, one denied having sphincter movements, while the other affirmed their presence. The age and level of the lesion could not be correlated with the phantom; the intensity, however, seemed to diminish with time.

(*b*) Bladder: A phantom was present in 7 patients and absent in 39 patients; its presence was undecided in two patients and was not determined in two others. The phantom consisted of a sensation of distention, whereas the bladder was actually empty in five patients, and in the remaining two it consisted of a continuous sensation of micturition. In four patients with distention phantom of the bladder, a dis-

tention phantom of the rectum was present also. In one of the two patients with micturition phantom, the phenomenon could be induced by drinking water. One patient (segmental level, 11th to 12th thoracic) claimed that he had a distention phantom of the bladder for the first six months after the injury and lost it thereafter. He is the one, mentioned above, who lost voluntary phantom movements of the knee two years after injury. The rest of the patients showed no evidence of correlation with age or level of lesion. The intensity seemed to decrease with the duration of the time interval.

(*c*) Penis: A penis phantom was present in 19 patients and absent in 30 patients, and one patient was undecided as to its presence. Nine of the 19 patients reported that the site of the phantom was at the tip or glans of the penis; 3 patients specified the shaft, and 7 could not accurately describe the form of the phantom.

(*d*) Erection Phantom: An erection phantom was present in 14 and absent in 34 patients; for two its presence was undetermined. Erection phantoms appeared with and without conscious erotic stimulation. One patient with a segmental level at the third thoracic reported that he had phantom erections until six years after injury when they disappeared. Another patient with a segmental level at the fifth thoracic lost phantom erections within the first year after injury. Three patients lost the phantom after anterolateral chordotomy. Except in the two cases cited, no

Combination of Penis Phantom, Actual Erection, and Erection Phantom

Penis phantom	+	0	+	0	+	?	+	0	0	0	?	
Actual erection	0	+	+	0	+	+	0	0	+	+	+	
Erection phantom	+	0	+	0	0	x	0	+	x	+	+	
	3	17	3	4	11	1	2	3	1	4	1	50

+ Indicates presence; 0, absence; ?, questionable presence, and x, presence undetermined.

correlation of erection phantom could be established with the time interval after injury or with the patient's age or the level of the lesion.

The combination of penis phantom, actual erection, and erection phantom is presented in the accompanying table.

Actual erections were present in 38 and absent in 12 patients. In five cases, erections had been abolished by a subarachnoid alcohol block. This would bring the number of initial erections to 43, which is in line with previous experience.[15]

GROUP 2: *Paraplegia with Amputations* (Seven Patients).—Patients 2 and 5 are additional patients, while the remaining five are included in Group 1.

CASE 1.—F. W., a man aged 29, had an amputation of the upper third of the left thigh after injury by a shell fragment on Dec. 4, 1943. He had a compression fracture of the 12th thoracic vertebra, with subsequent paraplegia below the level of the 10th to the 11th thoracic segment on Sept. 4, 1948, almost five years after amputation.

Amputation Phantom, Left Leg Prior to Injury to the Cord: He experienced severe phantom pains for the first four months; these spontaneously subsided except for short periods of pain, which was sharp and "made him jump." The interval between pain periods was 10 days, but he had occasional attacks three to four times a day. The pain was localized to the foot and knee; there was gradual telescoping of the foot until it was felt at the level of the knee.

15. Bors.[2a] Bors, E.; Engle, E. T.; Rosenquist, R. C., and Holliger, V. H.: Fertility in Paraplegic Males: A Preliminary Report of Endocrine Studies, J. Clin. Endocrinol. **10**:381-398, 1950.

Amputation Phantom, One Year After Injury to Cord: There had been complete cessation of phantom pain since the injury.

Comparison of Amputation Phantom with Paraplegia Phantom: The patient was less aware of the amputation phantom; he had to concentrate in order to evoke it. The foot was still felt at the level of the knee; he could voluntarily move the toes and ankle and, to a less degree, the knee. He was more aware of the paraplegia phantom and did not need to concentrate in order to recall it. He could move voluntarily all joints from the toes up. Four weeks after the cord injury, the "cramped position" of the leg relaxed. This position was identical with that which he observed while he was transported in the back seat of a car after the injury to the cord.

Case 2.—C. B., a man aged 25 (not reported in Group 1), had complete paraplegia below the 10th thoracic segment after a bullet wound at the same vertebral level sustained on June 10, 1944. Exarticulation of the right leg because of infection was carried out at another hospital on Dec. 8, 1949, five and a half years after injury to the cord. The left leg was in severe contracture of 90 degrees flexion at the knee.

Comparison of Amputation Phantom with Paraplegia Phantom One Year After Amputation: There was no change; the unit was maintained by tingling; shrinkage (telescoping) was absent. The position was straight (dissociated from actual contracture), unchanged since the time of injury to the cord. Distinct were the toes (big toe was better than the rest), heel, ankle, shin, calf, and hamstring muscles. Voluntary phantom movements were present in the big toe, ankle, calf (associated with hamstrings), hamstrings, and anal sphincter. Rectum and bladder phantoms were absent; a penis phantom was present. Erections were present; there was no erection phantom.

Case 3.—C. S., a man aged 23, sustained a compression fracture of the 11th thoracic vertebra in an automobile accident on Feb. 22, 1947, with cystic degeneration of the cord at the 11th thoracic segment and segmental levels at the 11th to the 12th thoracic on the left and at the 10th to the 11th thoracic on the right. The right leg was amputated 15 cm. below the knee because of gangrene on April 25, two months after injury to the cord.

Comparison of Amputation Phantom with Paraplegia Phantom Two and a Half Years After Amputation: No difference in unit, position, distinct parts, or voluntary movements of the phantoms and no shrinkage was apparent. Until four months after the amputation, he believed that the amputation phantom may have been slightly more pronounced than the paraplegia phantom.

Case 4.—G. Y., a man aged 34, sustained a shell fragment injury at the first to the second lumbar level on June 13, 1944, with subsequent sensory levels at the second lumbar dermatome on the left and at the 12th thoracic to the 1st lumbar dermatome on the right, and a motor level at the 4th lumbar on the left. Amputation at the upper third of the right thigh was performed a few weeks after injury.

Comparison of Amputation Phantom with Paraplegia Phantom Six Years After Amputation: No difference in unit, position, or representation of distinct parts was apparent. Except for movements of the big toe, present in the amputation phantom but absent in the paraplegia phantom, voluntary movements in the two phantoms were equal. There was no shrinkage. There were occasional shooting pains in the right stump. There was also some burning pain in the paralyzed left leg.

Case 5.—D. C., a man aged 29, sustained a fracture of the 11th thoracic segment with subsequent complete paralysis at the segmental level of the 12th thoracic in a railroad accident on Feb. 12, 1944. At that time, the middle, ring, and little finger of the right hand had to be amputated at the metacarpophalangeal joints. A painful amputation phantom existed for five months; thereafter, it became painless and disappeared completely after one year. The paraplegia phantom persists unchanged.

Case 6.—K. T., a man aged 32, was injured in a truck accident on Jan. 1, 1945, sustaining severe injury of the left upper extremity, which necessitated amputation 10 cm. below the elbow joint, and a fracture dislocation between the first and the second lumbar vertebra, which sheared off the cauda equina. He sustained remote damage to the cord, without demonstrable vertebral changes on roentgenographic examination, which rendered him completely paralyzed at the segmental levels of the seventh thoracic vertebra. He wore a prosthesis of hook type with double action at the elbow joint.

Left Amputation Phantom: The patient presented a cramped, claw-like position of the fingers, with the thumb pressing into the palm. He could not relax the fingers. The forearm was supinated, palm up. There was no movement of the wrist phantom. There were occasional, tolerable pains, from the thumb "digging" into the palm. The hand had not decreased in size. There was no *choc à blanc*. The length of the right forearm was 38 cm. With the patient sitting up straight, the length of the left amputation phantom was 27 cm.; with the patient bending forward, 33 cm.; with the stump submerged in cold water, 29 cm. (clonus of stump); with the stump submerged in warm water, 37 cm.; with the normal right hand submerged in cold water, 23 cm., and with the normal right hand submerged in warm water, 37 cm. Submersion of either the right hand or the left stump in cold or warm water had no bearing on the paraplegia phantom. When the patient wore his prosthesis, the phantom entered the artificial arm, and the tip of his middle finger coincided exactly with the hook.

Comparison of Amputation Phantom with Paraplegia Phantom: The amputation phantom was more distinct than the paraplegia phantom. While the patient had to concentrate in order to recall sensations from his legs, he could instantly describe those from his lost upper extremity.

Case 7.—M. M., a man aged 28 (not included in Group 1), was rendered tetraplegic on May 18, 1945, by a bullet wound in his neck, which did not cause demonstrable damage to the vertebral column. Six months later, function of both lower extremities and limited function of the left upper extremity started to return. The right upper extremity became contracted, owing to excessive spasticity. Sensation in the upper extremities was impaired, with anesthesia to cotton and hypalgesia and analgesia to pinprick, respectively, in the sixth to the eighth, the sixth to seventh, and the eighth cervical dermatome.

At the time of report (five and a half years after injury) the patient was able to walk with one person aiding him. Amputation of the right upper extremity at the midhumerus was performed on Oct. 12, 1950, five years and five months after the cord injury.

Amputation Phantom Two Months After Amputation: Shrinkage: The length was 20 cm., as against 40 cm. for the normal (left) forearm. Sensation: The fingernails needed clipping. The patient suffered previously repeatedly from paronychia. Movements: He could not oppose the thumb and little finger but could flex and extend all phantom fingers; the wrist was movable; the elbow was movable (he underwent arthrodesis on Feb. 5, 1948 and had a temporary decubitus ulcer of the olecranon, which he still felt). There was no *choc à blanc*. Stump sensation was intact. Amputation phantom: With the stump submerged in cold water the phantom elongated from 20 to 45 cm.; with the stump submerged in warm water, the phantom shortened from 20 to 10 cm.; with the left hand submerged in cold water, it shortened from 20 to 13 cm.; with the left hand submerged in warm water it lengthened from 20 to 38 cm.; with the patient bending forward or backward, there was no effect.

Group 3: *Paraplegia with Anterolateral Spinothalamic Tractotomy* (12 Patients).[16]—All these patients are included in Group 1. Their original lesions were low, between the 12th thoracic and the 4th lumbar level. The lesions were of the lower motor neuron type. The chordotomies were performed at the first thoracic vertebral level. All patients underwent psychological and psychiatric exploration prior to surgery. The operation was successful in 10; it abolished the excruciating pain, while a burning or tingling sensation remained, which was tolerated by the patient without the use of drugs being necessitated. The surgical intervention raised the analgesia level by a minimum of four segments in all but one of the successfully treated patients. The exceptional patient was completely relieved, although his level of analgesia ascended only from the original 12th to the 11th thoracic dermatome on the left and from the 11th or 12th to the 10th thoracic dermatome on the right. One of the two patients considered failures improved, according to his statement by 50%, but he is known to have continued his preoperative drug addiction. The other patient had a relapse of a similar type of sharp pain five months after injury, although the level of analgesia was raised to the sixth thoracic dermatome.

16. The operations were performed by Dr. John D. French, Chief of Neurosurgery.

Another organic deficit which occurred in addition to the rise in the level of analgesia concerned the sexual function. Erection, ejaculation, and orgasm were lost in three patients. Their analgesic levels were raised by 7 to 10 segments. One additional patient lost erections (he was one of the unsuccessfully treated patients whose analgesic level failed to ascend after operation). The sexual function remained unaltered in the remaining eight patients; among them were two who retained erection, ejaculation, and orgasm. Their levels were raised by two to four segments.

The following changes of phantom phenomena were observed: Three patients lost the erection phantom postoperatively; two of these lost also actual erection, while the third never had erections after his injury.

Two patients seemed to notice a difference in the toe phantom: One claimed that his phantom was more movable and elaborated that this was due to loss of the inhibitory effect of the concurrent pain on attempt to move; the other stated that he had less "strength" to move the phantom.

Two patients referred to the instep phantom: One claimed that it appeared after the operation, while it was absent before operation; the other stated that he lost the "cramp" in the phantom.

Three patients noticed changes in the calf phantom: Two reported that it became movable on volition after chordotomy; the third lost "strength" to move his phantom, as compared with his preoperative impression.

One patient related that his ankle and knee phantom became movable after the chordotomy; he was one of the two who noticed the same effect in the calf phantom, and it was he who failed to improve because his level of analgesia was not raised by the operation.

One patient observed that the rectal-distention phantom disappeared and that he lost the pain on micturition which he experienced before operation.

COMMENT

The incidence of a phantom in this series was 100%; this figure is true not only for the 50 patients whose phantom sensations were studied in detail, but for an equal number of patients who were questioned as to the general presence of phantoms. The incidence of a paraplegia phantom is at least the same as that of an amputation phantom, which was reported to occur in from 95 to 100% of the cases.[17]

GROUP 1: *Unit; Shrinkage; Position* (Chart 1).—The phantom limb is a unit or entity[18] which is derived from tactile, kinesthetic, and visual impressions.[6a] These impressions lead to engrams, which form a surface, postural, and visual model of the body.[19] In this respect, the paraplegia phantom resembled closely the amputation phantom. The sensations were projected to the surface in the majority of patients (37); 9 exhibited predominantly postural models. Only two patients had disturbances of continuity as a "gap or hole," described by Riddoch[1a,b] also for patients with a spinal cord injury, and only one had only a "visual" unit.

17. (*a*) Mitchell.[6a,b] (*b*) Pitres, cited by Stone.[4] (*c*) Leriche.[11d] (*d*) Ewalt, J. R.; Randall, G. C., and Morris, H. D.: The Phantom Limb, Psychosom. Med. **9**:118-123, 1947.

18. Bayley, A. A., and Moersch, F. P.: Phantom Limb, Canad. M. A. J. **45**:37-42, 1949.

19. Head and Holmes.[13a] Riddoch.[1c]

One is tempted to assume that paraplegia phantom and amputation phantom have certain similar aspects. Before the theory is proposed, a brief review of pertinent data from the literature seems necessary.

Adrian [20] demonstrated that the depolarization effect at the cut end of an isolated mammalian nerve creates a stimulation which communicates itself to adjacent fibers. Renshaw and Therman [21] stimulated posterior roots caudal to a section of the posterior columns of the cord and obtained an effect of cross stimulation at the cut end by excitation of adjacent neurons, which discharged centrifugally. Granit, Leksell, and Skoglund [22] observed that nerve impulses set up in a motor root are transmitted to sensory fibers at the cut end of a peripheral nerve and can be demonstrated in the sensory root of the same cord segment. This effect of cross stimulation is greatly facilitated if the "artificial synapse" is due to fresh damage; cross stimulation can be observed also when the nerve is not cut, but is either crushed or exposed only to mechanical pressure of moderate degree. The work of Granit, Leksell, and Skoglund has served as a working hypothesis to explain the success of sympathectomy in the treatment of causalgia.[23] In addition to the "artificial synapse," the internuncial pools [11f] play a role in the forming of reverberating circuits, which tend to ascend from spinal levels cephalad [23d] until they reach the cortex.

If one considers these facts and recalls that Riddoch [1c] proposed the theory that the phenomena of amputation phantoms are governed by the twin processes of peripheral stimulation and central inhibition, it takes only a small step farther to apply the theory of cross stimulation to the damaged or severed spinal cord, in which the lesion would serve as an "artificial synapse." It is conceivable that this part of the cord assumes the part which the peripheral nerve plays in the amputation phantom and that stimuli initiate reverberating circuits from the damaged region of the cord through internuncial pools to cortical levels.

This theory receives additional support from the painful paraplegia phantom, because the pain of the paraplegic patient resembles clinically that of the causalgic patient and is commonest with lesions of the cauda equina; in the light of the foregoing discussion, it is reasonable to assume that the damaged filaments of the cauda equina act as an "artificial synapse." Further support of this assumption may possibly be derived from the observation that the dissociation of phantom position recedes with time. The stabilization through healing of the central end of the cord may well reduce the initially more pronounced facilitation, which is presumably greater at a freshly damaged region.

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20. Adrian, E. D.: The Effects of Injury on Mammalian Nerve Fibres, Proc. Roy. Soc., s.B, London **106**:596-618, 1930.

21. Renshaw, B., and Therman, P. O.: Excitation of Intraspinal Mammalian Axons by Nerve Impulses in Adjacent Axons, Am. J. Physiol. **133**:96-105, 1944.

22. Granit, R.; Leksell, L., and Skoglund, C. R.: Fibre Interaction in Injured or Compressed Region of Nerve, Brain **67**:125-140, 1944.

23. (a) Doupe, J.; Cullen, C. H., and Chance, G. Q.: Post-Traumatic Pain and the Causalgic Syndrome, J. Neurol., Neurosurg. & Psychiat. **7**:33-48, 1944. (*b*) Nathan, P. W.: On the Pathogenesis of Causalgia in Peripheral Nerve Injuries, Brain **70**:145-170, 1947. (*c*) Mayfield, F. H.: Causalgia, Am. J. Surg. **74**:522-526, 1947. (*d*) McCulloch, W. S.: Physiological Processes Underlying Psychoneuroses, Proc. Roy. Soc. Med. (Supp.) **42**:71-84, 1949.

Cerebral lesions of paraplegic patients will lead to physiologic disturbances [19d] of the body scheme, or anosognostic conditions, as described by Weinstein and Kahn. [24] Imperception of paralysis was observed in a patient with syringomyelia,[25] in whom necropsy revealed hydrocephalus, a hemorrhagic cyst of the left hemisphere, and atrophy of the corpus callosum. My colleagues and I observed a patient with a similar, though completely reversible, condition, following a severe cerebral concussion, sustained in the same accident which led to a physiologic transection at the segmental level of the seventh thoracic. This patient (not included in this series) remained for two months unaware of his injury; he was also spatially and temporally disoriented.

Telescoping of the amputation phantom is a common finding [26] and is only exceptionally absent.[27] Riddoch [1a,b] related that in his third case of traumatic paraplegia "the feet lay quite detached somewhat nearer the knees than normal," and he stated, furthermore, that "it has not been infrequent to obtain the description of apparent shortening of the legs from the knees to the ankles." He did not reiterate this observation in his later paper.[1b] I am unable to confirm this earlier observation of Riddoch's, because I did not observe shrinkage in a single patient with extensive damage to the spinal cord.

The length of the phantom limb could not be influenced by a change of position or submersion of the upper extremities in warm or cold water in 12 cases in which this was tried. This experience differs from that with amputees, reported by Jung.[8e]

Shrinkage of the amputation phantom was explained either by diminution of sensory impulses, with subsequent diminution of the phantom outline and resulting telescoping effect and acceptance of a new body scheme [1c] or by recession of an initial hyperexcitability of the sensory cortex.[26d]

The available data of the literature, combined with our own observations, seem to indicate the level and degree of cord injury which abolish telescoping:

Telescoping was described in two cases of lesions of the brachial plexus with and without amputation.[28] In case 7 (M. M.) telescoping followed amputation of the right arm five years after an incomplete lesion of the cervical portion of the cord. In contrast, no shrinkage was noted by any of our three patients (Case 2 [C. B.], Case 3 [C. S.], Case 4 [G. Y.]) whether the leg was amputated five and one-half years, two months, or two weeks after the injury to the cord. Their respective levels were the 10th and 11th thoracic and 2d lumbar (cauda equina). It would seem that a lesion of the cord must be extensive and a nerve injury must be above the spinal ganglia in order to prevent the phantom from telescoping.

The cord, then, shares this property in preventing phantom shrinkage with the higher centers. The reports on anatomic disturbances of the body scheme [29] do not

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24. Weinstein, A., and Kahn, R. L.: The Syndrome of Anosognosia, Arch. Neurol. & Psychiat. **64**:772-791 (Dec.) 1950.

25. Stengel, E., and Steele, G. D. F.: Unawareness of Physical Disability (Anosognosia), J. Ment. Sc. **92**:379-388, 1946.

26. (*a*) Riddoch.[1e] (*b*) Guéniot.[8] (*c*) Mitchell.[6a,b] (*d*) Henderson, W. R., and Smyth, G. E.: Phantom Limbs, J. Neurol., Neurosurg. & Psychiat. **11**:88-112, 1948.

27. Gerstmann, J.: Problem of Imperception of Disease and of Impaired Body Territories with Organic Lesions: Relation to Body Scheme and Its Disorders, Arch. Neurol. & Psychiat. **48**:890-913 (Dec.) 1942.

28. Mayer-Gross.[2] Riddoch.[1c]

29. Schilder.[13b] Nielsen.[13d] Weinstein and Kahn.[24]

mention telescoping of an extremity which the patient does not recognize as his own but projects to someone else.

Riddoch [1] and Mayer-Gross [2] reported dissociation of the phantom from the actual position of the limb in cases of spinal cord injuries. In the case of Mayer-Gross, with a cervical lesion, this dissociation was limited to the upper extremities.

We observed dissociation in 21 patients and found it to be a temporary phenomenon, which lasted from a few days to several months. Thereafter the visual impression prevailed. The possible role of fresh damage to the cord in dissociation and decrease of stimulation from a stabilized scar has already been discussed. Foerster [7] believed that dissociation of the amputee was caused by engrams which were created by the last stimulation of the peripheral nerves at the time of injury.

Two patients did not feel their extremities at the time of injury; this phenomenon was described previously by Riddoch [1c] and Schulte [30]; this lack of a postural phantom led to an anosognostic interpretation by one who did not recognize the extremities as his own. The postural phantom seemed to depend on the initial visual impression of two patients at the time of injury. The visual impression seems to be of less importance for the postural phantom of the paraplegic patient than for that of the amputee.

Detailed Incidence (Chart 2).—Parts of the body endowed with rich sensory endings, such as the fingers, toes, hand, and foot, are most distinct in the phantom of the amputee.[31] These parts have the greatest representation in the sensorimotor cortex. It is not surprising, therefore, that the incidence of the toe, instep, heel, ankle, and shin phantom of the paraplegic patient follows closely the pattern of the homunculus of Penfield and Boldrey.[12c] These parts come in contact with the outer world almost in the order of frequency illustrated in Chart 2. The second peak, seen in Chart 2, is at the calf and at the knee, whence the declining slope starts toward the hip joint. Proprioceptive, rather than exteroceptive, impulses originate from the muscles and the knee joint, which is the largest in the body, and these structures are important for the postural model; nevertheless, this pattern, too, fits the homunculus of cortical representation.

Movements of the Phantom (Chart 3).—Mitchell [6a] reported that freedom of volitional movements of the phantom are present only in a small number of amputees, and Jung [8e] believed that they originate centrally. Riddoch [1c] did not observe willed movements of paraplegia phantoms; our findings differ from those of Riddoch, and the incidence of volitional movements of the paraplegia phantom is reflected in Chart 3. There is a similarity between Chart 2 and Chart 3: The decline of the motility from the toes toward the hip joint reminds one of the previously mentioned representation in the sensorimotor cortex. The willed movement of the anal-sphincter phantom exceeds the movements of all other muscle phantoms. This is not surprising in view of the high degree of differentiation of this muscle, which is built to distinguish between gaseous, liquid, and solid matter.

When a patient is asked to perform a willed phantom movement, his behavior and facial expression resemble that of a person who attempts to recall a fact from memory with an obvious effort to concentrate, not focusing his gaze, but rather

30. Schulte, W.: Die Psyche der Rückenmarksquerschnittsverletzten, Nervenarzt **18**:28-34, 1947.

31. Mitchell,[6a,b] Riddoch,[1c] Henderson and Smyth.[26d]

staring into space or closing his eyes. One is tempted to believe that this behavior pattern reflects the initiation pattern and that the volitional phantom movements start cortically. It is true that the area of "recall" for willed movements is not yet known, but it may be suspected to occupy parts of the parietal lobe.[32] It seems reasonable to assume that it is related to engrams of the body scheme which are not identical with those of somesthetic sensation [13d]; the latter have their highest integrating level in the supramarginal gyrus, demonstrated by Evans' [12b] limited ablation experiments of this area, which were followed by extensive and permanent somesthetic deficit.

It is an appealing idea to assume that the same working hypothesis—only in reverse—could be applied for the willed phantom movement which was described above for phantom sensation and postural dissociation. The willed movement of the phantom may well originate from the cortical area of recall with centrifugal impulses, which may close the circuit by cross stimulation at any level—cerebral, internuncial spinal, or "artificial synapse" of the cord—thus fulfilling the dictum that sensation and motion form a single, indivisible, continuous process.[33] The resulting illusion of the completed movements reaches occasionally such intensity that many a patient is forced to check it by visual control.

With the exception of one case in which willed movement of the knee phantom was lost two years after injury, the time element played no part, contrary to the experience with postural dissociation.

While symmetrical associated movements were reported by only one patient, homolateral associated movements of the calf, knee, thigh, and hip were observed by a small number. This experience, too, seems to point to the higher centers as the origin of the illusion.

Phantom of Unpaired Organs (Chart 4).—Other amputation phantoms, such as the breast, penis, and erection phantoms, were reported by Mitchell,[6b] who quoted Ruschenberger. Riddoch [1c] mentioned, in addition, phantoms of the nostrils and the tip of the nose; he believed that the erection phantom was connected with engorgement of the stump. Gallinek [34] did not confirm any of these observations and concluded that amputation phantoms depended on muscle mass. Recently, Heusner [35] described two cases of penis phantom following amputation. One patient had a painless erection phantom, which disappeared four years later, when the patient sustained a partial injury to the cord; the other patient, with a painful phantom, lost pain and phantom sensation after bilateral chordotomy. We were unable to find references on paraplegia phantoms of the rectum, bladder, penis, or erection.

One may presume that the rectum and bladder phantoms are of postural rather than of surface type and that they are referable to impressions related to a change of intravisceral pressure.

32. Nielsen, J. M.: Personal communication to the author, Jan. 6, 1951.

33. Goody, W.: Sensation and Volition, Brain **72**:313-339, 1949.

34. Gallinek, A.: The Phantom Limb: Its Origin and Its Relationship to the Hallucinations of Psychotic States, Am. J. Psychiat. **96**:413, 1939.

35. Heusner, A. P.: Phantom Genitalia, Tr. Am. Neurol. A. **75**:128-131, 1950.

In contrast to this, the penis phantom is of the surface type and is probably connected with the richness in sensory receptors. The order of incidence—11 rectum phantoms and 7 bladder phantoms, as against 19 penis phantoms—may furthermore be explained by the paucity of somatic nerves connected with these hollow viscera.

The erection phantom could be understood as composed of both factors, surface and postural, the latter being related to the changes of pressure in the corpora cavernosa. Thus, the erection, rectum, or bladder phantom may result from postural impressions of autonomically innervated smooth muscle.

While there can be no doubt that these phantoms as carriers of primordial desires are deeply rooted and originate perhaps centrally oftener than not, there are a few observations which point to a peripheral origin also: The rectal distention phantom or defecation phantom abates in severity with time. In one case, not recorded above, a defecation phantom disappeared completely six months after injury. Most striking are three cases in which an erection phantom was lost after chordotomy. It could be argued that two of the patients lost actual erections also, owing to severance of parasympathetic tracts, which are said to travel close to the gray matter in the anterolateral column,[36] and that the interruption of centrifugal pathways which control psychogenic erection led to the loss of phantom erection. However, the third patient lost phantom erections after chordotomy without having ever had erections since the time of injury to the cord. This suggests that phantom erections may well originate from stimuli at the central stump of the cord and disappear with severance of centripetal pathways over which these impulses travel. These observations, of abolition of a rectum and erection phantom after chordotomy and that of defecation phantom with time, indicate that such a phantom may well have a peripheral cause also.

Thus, phantoms from unpaired organs, though rare, occur with paraplegia and may be of dual origin, central and peripheral.

Group 2: *Paraplegia with Amputation.*—The effect of a cerebral accident on an amputation phantom has been described by Head and Holmes,[13a] and this observation led to various therapeutic attempts to relieve the pain in the phantom; no reference could be found regarding a combination of paraplegia and various amputations of extremities.

The outstanding feature has been discussed previously, namely, prevention of telescoping of the amputation phantom by a concurrent complete lesion of the cord. Other interesting points concern the effect of a cord injury on an amputation phantom of earlier date, the acuity of amputation phantom versus paraplegia phantom in the same patient, and the effect of an earlier partial lesion of the cord on an amputation phantom of later date.

When the lesion of the cord was superimposed (Case 1, F. W.) on an old amputation phantom, the previously sporadic pain ceased instantly and completely. No further shrinkage occurred, though it is conceded that the maximum telescoping effect might already have been reached with the foot projected at the knee. The amputation phantom, though retained, was at once overshadowed by the paraplegia

36. Hyndman, O. R., and Wolkin, J.: Anterior Chordotomy: Further Observations on Physiologic Results and Optimum Manner of Performance, Arch. Neurol. & Psychiat. **50**:129-148 (Aug.) 1943.

phantom. It is interesting to note that a level (10th to 11th thoracic) of a physiologic transection sufficed for the cessation of the painful amputation phantom, while a partial interruption by chordotomy at the same level would be of doubtful value. This is understandable in the light of Foerster's [11a] studies of pain pathways. If an extensive cord injury coincides with, or precedes, the amputation of a lower extremity, no notable difference is apparent between the paraplegia and the amputation phantom.

The acuity of the amputation phantom as compared with the paraplegia phantom seems to depend on the extent of the amputation. The paraplegia phantom of the legs exceeded the amputation phantom (Case 5, D. C.) in intensity when the third, fourth, and fifth fingers were lost; exactly the opposite was true in a case of amputation of the left forearm (Case 6, K. T.). This patient was much more aware of the amputation phantom of the arm than of the paraplegia phantom of the legs.

There was a slight difference in experimental results between a "simple" amputation phantom of the forearm without damage to the cervical portion of the cord (Case 6, K. T.) and an amputation phantom of the arm combined with a partial lesion of the cervical region (Case 7, M. M.). While the length of the "simple" amputation phantom changed with the posture of the patient,[8c] the "cord" amputation did not. Submersion of the "simple" stump in warm water produced a prompt lengthening effect, while the opposite result was obtained from the "cord" stump. However, when the opposite upper extremity was treated with a warm or a cold bath, the "simple" and the "cord" phantom responded identically with lengthening and shortening, respectively. Phantom sensations from submersion in warm or cold media are said to be linked to vasomotor responses,[8d] and it is conceivable that the ipsilateral paradoxical reaction of the "cord" stump was caused by a vasomotor disturbance from the lesion of the cord. Other minor differences between the "simple" and the "cord" phantom concerned position, degree of volitional motility, and pains. The "simple" phantom was rigid, and there were the characteristic sensation of the thumb digging into the palm, the absence of willed movements, and occasional pain. The "cord" phantom arm was movable in the fingers, wrist, and even elbow joint, which actually had been ankylosed two years and eight months prior to amputation. The only limitation of phantom movement consisted of lack of opposition of the thumb and the little finger. The only dysesthetic experience was related to the nails, which "needed clipping," and to the olecranon, where the patient previously had a decubitus ulcer. It is mere conjecture to believe that the partial analgesia and anesthesia, caused by the cord injury, were the reasons for the presence of willed movements and absence of pain, although the inhibitory effect of pain on volitional phantom movement was observed.[1c] The phantom telescoped in spite of the partial damage to the cord, which was of predominant motor type.

GROUP 3: *Paraplegia and Spinothalamic Tractotomy.*—Pain accompanying spinal cord injuries was described by Riddoch.[1a,b] It is common with lesions of the cauda equina [37] and consists usually of two components: a tolerable burning sensa-

37. (*a*) Davis, L., and Martin, J.: Studies upon Spinal Cord Injuries: II. The Nature and Treatment of Pain, J. Neurosurg. **4**:483-491, 1947. (*b*) Freeman, L. W., and Heimburger, R. F.: Surgical Relief of Pain in Paraplegic Patients, Arch. Surg. **55**:433-440 (Oct.) 1947. (*c*) Bors.[3a]

tion and an unbearable shooting pain, which radiates along the paralyzed extremity down to the toes and occasionally up to the testes. There is a certain clinical similarity between causalgia and the painful paraplegia phantom. The pain is aggravated by emotional disturbance, sudden noise, or an attempt at willed movements in the phantom. Vasodilatation is at least as common as vasoconstriction. The pain can be compared also with the "pain in the phantom,"[11d] which resembles, in turn, causalgic pain.[38]

There is a resemblance between the behavior pattern of paraplegic patients suffering from "tic douloureux"[3a] and that of amputees with a painful phantom. The amputee applies pressure to the stump and sciatic nerve,[18] the paraplegic exerts traction on the cord by extreme flexion of the head and accompanies this with occasional pressure to the thigh. The pain differs from "stump pain" of the amputee,[11d] inasmuch as the latter is confined to the stump and does not interfere with volitional movement of the phantom (Case 4, G. Y.).

Hazouri and Mueller[39] demonstrated that the pain threshold of paraplegic patients prior to chordotomy was elevated, owing to endurance, and returned to normal after successful intervention. Chordotomy has proved successful[40] with the painful paraplegia phantom rather than with the painful amputation phantom[11d] of the extremities. A painful testis phantom following orchiectomy was abolished by anterolateral tractotomy.[38]

While all patients in this series who underwent successful chordotomy lost the "shooting" phantom pain, they retained the burning sensation of the surface, and it must be concluded that this sensation did not travel by the spinothalamic tracts. Whether it could have been abolished by additional sympathectomy, thus proving that it is sympathetic in origin,[37b] is only a matter of conjecture. Inasmuch as this sensation did not interfere with the patient's comfort, there was no indication for another operation. The sympathetic nerve fibers play an important part in the painful phantom of the amputee,[41] but their role in the painful paraplegia phantom is not clearly defined.

The success of chordotomy in the treatment of the painful paraplegia phantom suggests that its origin can be explained by the previously mentioned working hypothesis of the "artificial synapse." The failure of chordotomy in one of our cases, despite the raising of the level of analgesia, could possibly be explained in analogy with the experience in causalgia,[23d] namely, that the reverberating circuits have a tendency to progress cephalad. Riddoch[1c] believed that painful stimuli overcome the central psychophysiological inhibition in cases of a painful amputation phantom.

The effect of chordotomy on the rectum and erection phantoms has been discussed previously. Other effects concerned the willed movement of the phantom. In four cases the relief from pain facilitated voluntary phantom motion after the

38. Pisetsky, J. E.: Disappearance of Painful Phantom Limbs After Electric Shock Treatment, Am. J. Psychiat. **102**:599-601, 1946.

39. Hazouri, L. A., and Mueller, A. D.: Pain Threshold Studies on Paraplegic Patients, Arch. Neurol. & Psychiat. **64**:607-613 (Nov.) 1950.

40. Davis and Martin.[37a] Freeman and Heimburger.[37b] de Saussure, R. L.: Lateral Spinothalamic Tractotomy for Relief of Pain in Cauda Equina Injury, Arch. Neurol. & Psychiat. **64**:708-714 (Nov.) 1950.

41. Foerster, footnotes 7 and 11a. Echlin, F.: Pain Responses on Stimulation of the Lumbar Sympathetic Chain Under Local Anesthesia, J. Neurosurg. **6**:530-533, 1949.

dynamic component of the postural phantom was no longer inhibited. This concurs with Riddoch's [1c] observation on amputation phantoms. The syndrome of pain in the extremities with micturition was abolished by chordotomy in one patient; such a syndrome was described by Mitchell [6b] in painful amputation phantoms and by Heusner [35] in a painful testis phantom; tingling sensation of the stump of the amputated lower extremity during micturition occurs frequently, according to Henderson and Smyth.[26d]

PSYCHOLOGICAL IMPLICATIONS

The mutual dependence of the painless or painful phantom limb and the psychological condition of the amputee has been reported by Schilder,[13b] Gallinek,[34] Riddoch,[1c] Ewalt, Randall, and Morris,[17d] and Kolb.[42] These authors stressed the importance of psychological factors, such as fear or anxiety, for the phantom shape, the effect of organic conditions of the peripheral nerves on phantom pain, and the relation of psychosis and various mental states, stable, psychopathic, or neuropathic, to the phantom of the amputee. The absence of the disability in the dream life of the amputee has been observed.[43]

Psychological and psychiatric studies of paraplegic patients have failed so far to report phantom phenomena, and, therefore, their significance for some of the behavior patterns associated with paraplegia.[44] The role of the body scheme was but briefly mentioned in reports of psychological studies.[44b,d] Except for the sexual dreams of paraplegic patients,[45] the dream life has not been investigated. Contrary to the dream of the amputee, that of the paraplegic reveals in some cases (own, unpublished data) a realization of the disability. Patients have reported dreams of wheel chair activity and crutch-and-brace ambulation, though dreams of normal walking are mentioned oftener. It usually takes a long time before true paraplegia enters the dream activity, resembling the experience with the dream life of the blind.[46]

Yet dreams and phantoms must be of significance for the adjustment to the injury. While the amputee is able to check the hallucination of his phantom limb by visual and tactile control, the paraplegic patient cannot do so. He can see and touch his paralyzed extremities, and his control must go past perception on to recognition of loss of function; this taxes his judgment. The dilemma of the average paraplegic patient becomes clear if one remembers that "throughout life, the cortex of general sensation rules over that of visual perception and recognition—and the proprioceptive sensation carries a greater conviction than exteroceptive sensation

42. Kolb, L. C.: Psychiatric Aspects of Treatment for Intractable Pain in the Phantom Limb, M. Clin. North America **34**:1029-1041, 1950.

43. (*a*) Lhermitte, J.: L'image de notre corps, Paris, Nouvelle revue critique, 1939. (*c*) Adler and Hoff.[8c] (*d*) Reichert.[8d] (*e*) Betlheim.[9b] (*f*) Charcot, cited by Lhermitte.[43a]

44. (*a*) Thom, D. A.; von Salzen, C. F., and Fromme, A.: Symposium on Problems in Post-war Medicine: Psychological Aspects of the Paraplegic Patient, M. Clin. North America **30**:473-480, 1946. (*b*) Schulte.[30] (*c*) Nagler, B.: Psychiatric Aspects of Cord Injury, Am. J. Psychiat. **107**:49-55, 1950. (*d*) Grayson, M.: The Concept of "Acceptance" in Physical Rehabilitation, Mil. Surgeon **107**:221-226, 1950. (*e*) Mueller, A. D., and Thompson, C. E.: Psychological Aspects of the Problem in Spinal Cord Injuries, Occup. Therapy **20**:86-95, 1950.

45. Bors.[8a] Shelden, C. H., and Bors, E.: Subarachnoid Alcohol Block in Paraplegia: Its Beneficial Effect on Mass Reflexes and Bladder Dysfunction, J. Neurosurg. **5**:385-391, 1948.

46. Scott, W. C. M.: Some Embryological, Neurological, Psychiatric and Psychoanalytic Implications of the Body Scheme, Internat. J. Psycho-Analysis **29**(Pt. 3):141-155, 1944.

through touch."[47] Unless some knowledge of medicine provides the patient with a basis for analysis, judgment, and eventual adjustment, the mere presence of the phantom invites false hopes for the return of function and may cause some of the autistic and indifferent attitudes. Patients have occasionally stated that amputation of the paralyzed limbs would theoretically make for easier adjustment, though such mutilating additional trauma would not be considered seriously by either the patient or an understanding observer. The pattern of the pretraumatic personality and the degree of attention focused on the body scheme by pretraumatic occupational or professional activity will be important factors for the adjustment.

SUMMARY

The phantom sensations of 50 patients with spinal cord injuries at various levels were studied in detail, as well as those of 7 patients with a combination of damage to the spinal cord and various amputations, and eventually the phantom changes of 12 patients following chordotomy.

1. The paraplegia phantom, like the amputation phantom, was derived from surface, postural, and visual impressions. In a majority of cases the unit of the limb was perceived from sensations projected to the surface, and in a minority, from postural sensations.

2. Contrary to the phantom of the amputee, (*a*) there was no telescoping effect or shrinkage, provided that the cord lesion was complete, and (*b*) the phantom length and position remained unaltered by postural changes of the body or by vasomotor stimulation of the intact extremities.

3. Dissociation of position occurred in a large minority (two-fifths) and disappeared with time.

4. The distribution of distinct parts of the phantom corresponded to the cortical sensorimotor representation and diminished in the order from toe to hip.

5. Volitional movements of the phantom, as well as occasional homolateral associated movements, were reported by the patients. The rate of incidence diminished in the order from toe to hip also; however, the willed movement, most frequently noted, occurred in the anal sphincter.

6. Phantoms of unpaired organs were observed. Those of bladder and rectum were rare (7 and 11, respectively); those of the penis and erection were somewhat more frequent (19 and 14, respectively).

7. When an amputation of paralyzed parts was performed at the time of the cord injury or later, the phantom behaved along the pattern of the paraplegia phantom, without change of length, provided that the lesion of the cord was complete; in the case of partial lesion of the cord the length and position of the phantom were subject to postural changes of the body and vasomotor stimulation.

8. Spinal cord injury following an amputation caused cessation of phantom pain, and no further shrinkage of the phantom was noted. The phantom of the absent extremity became less distinct than that of the present limb.

9. When cord injury coincided with amputation of a nonparalyzed part, the intensity of the amputation phantom, when compared with that of the paraplegia

47. Flechsig, cited by Nielsen.[18d]

phantom, depended on the extent of amputation. When only the third, fourth, and fifth fingers were lost, the paraplegia phantom was more intensive than the amputation phantom; but when the forearm was amputated, the situation was reversed, and the amputation phantom overshadowed the paraplegia phantom.

10. Chordotomy caused phantom changes in a small number of cases; it made the erection phantom, and occasionally the rectum phantom, disappear; it made some of the phantoms of toe, instep, and calf more pronounced, and in a very few patients it enhanced volitional movements of the phantoms (ankle, calf and knee). A resemblance of the painful paraplegia phantom with causalgia was observed.

The findings are discussed and compared with pertinent data from the literature referring to the amputation phantom.

A working hypothesis is proposed based upon the theory of cross stimulation at the "artificial synapse," in analogy to experience with causalgia.

This working hypothesis is applied to the respective phantoms, and data are discussed which suggest that some phenomena were possibly of a more centripetal origin (surface, dissociation, rectum, bladder), some of a seemingly more centrifugal origin (willed movement), and some of dual origin (erection).

The psychological significance of phantoms for the adjustment and behavior pattern of the patient is discussed.

Correspondence

ADRIAN'S SECOND SENSORY AREA

To the Editor.—In the transactions of the Philadelphia Neurological Society, published in the June 1951 issue of the ARCHIVES, pages 783-786, appears the abstract and discussion of a paper concerning Adrian's second sensory area (frontal and parietal operculum), by Dr. George D. Gammon and associates. Woolsey was the first to show that an irritation of this area in some cases produced ipsilateral and contralateral sensory seizures. The bilaterality was intriguing from the anatomical standpoint. The same author subsequently observed a homolateral sensory response on irritation of the classic postcentral convolution. Then followed other reports, particularly on unilateral chordotomy, which sometimes shows a homolateral sensory loss, demonstrating the absence of decussation of the spinothalamic tract. Moreover, a homolateral motor response was also observed by Penfield and others on irritation of the second sensory area. During the discussion by members of the Society, emphasis was laid on Sweet's work, demonstrating again the occurrence of ipsilateral or bilateral phenomena on unilateral irritation of the cortex or of the spinothalamic tract. Deviations in the sensory-motor pathways must, therefore, be admitted.

A striking example of a purely abnormal motor response was reported by me (*Med. Rec.* **71**:1032, 1907). It concerned a case of Jacksonian epilepsy, in which the convulsive movements were confined to the left side of the body. An exploratory operation was performed at Jefferson Hospital by the late Dr. DaCosta. On exposure of the right Rolandic area, there were evident dilated and tortuous veins, but the cortex was intact. For the purpose of studying the exact localization of the motor area, I decided to irritate the cortex with a faradic current. The least touch of the cortex would result in muscular contractions on the same side: Application to the upper angle of the exposed area would produce contraction in the arm and leg. Application to the middle of the area would be followed by contractions in the arm only. Application to the lower angle would produce contractions also in the face. In all these tests contractions were present exclusively on the right side. The well-known precautionary advice of Grünbaum and Sherrington was strictly observed; viz, the electrical application was first made on the ascending parietal convolution, and only then on the ascending frontal convolution.

The interpretation is a problem for histological research. There are two kinds of abnormal arrangements of the pyramidal tract. One is a bilateral absence of decussation: The crossed bundles are wanting on both sides of the cord, and the pyramids are represented by greatly enlarged Türck columns (ventral cerebrospinal tracts). The other is a unilateral absence of decussation; here the pyramid has never been divided, and it forms one large bundle of direct fibers. As all mammals except the elephant possess a decussation of pyramidal bundles, anomalies of decussation of tracts may be explained on the basis of degenerative factors during the growth of structures (abiotrophy).

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Abstracts from Current Literature

EDITED BY DR. BERNARD J. ALPERS

Physiology and Biochemistry

REFLEX MUSCULAR RESPONSES TO STIMULATION OF ARTICULAR NERVES IN THE CAT. E. GARDNER, Am. J. Physiol. **161**:133 (April) 1950.

The reflex function of articular nerves was studied in decerebrate and in decapitate cats. Simultaneous stimulation of all the fibers in articular nerves usually resulted in withdrawal, and, in decerebrate animals, in crossed extension as well. These reflexes apparently represent responses to nociceptive stimuli, since they were best developed only when nonmyelinated and small myelinated fibers were activated. These particular fibers are the ones from which free nerve endings in joints are derived.

The larger myelinated fibers in articular nerves arise from Ruffini-type endings, and stimulation of these fibers alone in decapitate animals was followed by multineuronal arc discharges over several ventral roots to the flexors of the thigh and leg. Other muscles, including some in the forelimbs, were sometimes activated as well. Responses to stimulation of the larger fibers in decerebrate animals were extremely variable. They were often absent. When present, they were usually flexor, although the primary response in two animals was extension of the hindlimb. Decerebrate animals, if subsequently decapitated, showed consistent flexor reflexes at lower intensities of stimulation, irrespective of the responses present during decerebration. It is postulated that the larger articular fibers and their central connections may subserve phasic mechanisms, such as locomotion. The reflexes these fibers mediate would in this case be more easily demonstrated in spinal animals and would more likely be inhibited in decerebrate animals.

ALPERS, Philadelphia.

EFFECT OF STRESS UPON GLYCOSURIA OF FORCE-FED DEPANCREATIZED AND OF ADRENALECTOMIZED-DEPANCREATIZED RATS. DWIGHT J. INGLE and JAMES E. NEZAMIS, Am. J. Physiol. **162**:1, 1950.

Ingle and Nezamis made rats mildly diabetic by means of partial pancreatectomy and then administered to them a medium carbohydrate diet. Twenty rats were adrenalectomized and treated with amounts of adrenal cortex sufficient to sustain the previous level of glycosuria. The authors found that the injections of 1.5% solution of formaldehyde decreased the glycosuria of the nonadrenalectomized rats, but a far more striking decrease in glycosuria occurred in the adrenalectomized rats. After cessation of the formaldehyde injections the glycosuria was reestablished at its preinjection level. The decrease in glycosuria tended to rise toward the prestress level before the injections of formaldehyde were stopped.

FORSTER, Washington, D. C.

MECHANISM OF MUSCULAR FATIGUE IN ADRENALECTOMIZED ANIMALS. E. RAMEY, M. S. GOLDSTEIN, and R. LEVINE, Am. J. Physiol. **162**:10, 1950.

Ramey, Goldstein, and Levine studied the isolated abdominal and diaphragm muscles of salt-treated adrenalectomized rats. These were studied in vitro, and the response to stimulation directly and through the motor nerve was observed. The time course of fatigue was determined and compared with that in normal controls. There was no significant difference in the work performance of muscle from normal and from adrenalectomized animals, even when such muscle strips were removed after muscular exhaustion was induced in vivo. The authors conclude that the well-established easy fatigability of the muscles of adrenalectomized animals in vivo is probably due to a failure of neurocirculatory adaptation and is not primarily a change at the muscle fiber itself.

FORSTER, Washington, D. C.

INVOLVEMENT OF THE NERVOUS SYSTEM IN INFECTIOUS MONONUCLEOSIS. T. C. BERNSTEIN and H. G. WOLFF, Ann. Int. Med. **33**:1120 (Nov.) 1950.

A review of the literature up to the time of publication of this paper revealed 28 reports, including 46 patients, describing involvement of the nervous system in infectious mononucleosis. The nervous system appears to be affected in less than 1% of patients with infectious mononucleosis.

Many parts of the nervous system may be affected in this disorder, the symptomatology depending on the site of maximal involvement. Serous meningitis, meningitis, encephalitis, meningoencephalitis, polyneuritis, and peripheral neuropathy have been described. It appears that the nervous system is directly invaded by the unknown agent causing the disease.

Clinical evidence of involvement of the nervous system occurs most commonly in males. The changes in the spinal fluid consist of an increase in lymphocytes and/or protein. Changes in the cerebrospinal fluid, as evidence of invasion of the nervous system without any sensory, motor, or mental defects, have been described, and there is suggestive evidence that this is a common occurrence. The prognosis in the series of cases described is excellent, 85% of the patients showing complete recovery.

Since the clinical picture produced by involvement of the nervous system is indistinguishable from that caused by many other agents, the authors advise that heterophil-antibody tests be made on all patients with "idiopathic" diseases of the nervous system. This is particularly important since the systemic signs of infectious mononucleosis may be minimal.

ALPERS, Philadelphia.

SOME FACTORS AFFECTING THE ACTION OF 2,4-DINITROPHENOL ON THE OXYGEN UPTAKE OF EXCISED RAT BRAIN. D. B. TYLER, J. Biol. Chem. **184**:711, 1950.

The changes in oxygen uptake with time as produced by graded concentrations suggest that dinitrophenol has at least two sites of action, each having distinctly different threshold concentrations. That required for augmentation is approximately 1×10^{-6} M; for inhibition the threshold concentration is fiftyfold. Concentration-action curves obtained from the brain of the newborn rat exhibit a flatter response to dinitrophenol. When lactate or pyruvate is used as a substrate, the response to graded concentrations of dinitrophenol is similar in direction to that found with glucose. On the other hand, the augmentation phase of action is absent when fumarate, citrate, malate, succinate, hexose diphosphate, or the Cori ester is used as a substrate.

PAGE, Cleveland.

MECHANISM OF INHIBITION OF ANAEROBIC GLYCOSIS OF BRAIN BY SODIUM IONS. M. F. UTTER, J. Biol. Chem. **185**:499, 1950.

It has been shown that Na^+ inhibits glycosis of homogenates of nerve tissue of the cotton rat. The effect was reversed by hexose diphosphate, although an imbalance of the phosphate esters persisted. The inhibition occurred at concentrations of Na^+ as low as 0.03 M. and was due neither to the increased tonicity caused by the addition of sodium chloride nor to the chloride ions. The inhibition by Na^+ was less marked in extracts. The effect of Na^+ upon various individual reactions of the glycolytic system was investigated. Hexokinase, phosphohexokinase, and the coupled oxidation-phosphorylation reactions were not significantly affected, but the transfer of phosphate from phosphopyruvate to adenylic acid was inhibited, and the dephosphorylation of adenosine triphosphate and adenosine diphosphate was stimulated. The stimulation of adenylpyrophosphatase was shown to be operative at low levels of Na^+ and to be dependent upon the presence of Mg^{++}. The significance of the effects of Na^+ upon the individual reactions has been discussed in relation to its effect upon glycolysis.

PAGE, Cleveland.

STUDIES ON THE STABILITY OF THE CHOLINE OXIDASE. G. S. EADIE and F. BERNHEIM, J. Biol. Chem. **185**:731, 1950.

Choline oxidase when partially purified rapidly loses its activity. The rate of loss is that of a first-order reaction, and equations are derived to describe the rate of reaction as modified by this factor. The inactivation is more rapid at pH 6.7 than at pH 7.8. Cystine and semi-

carbazide increase the rate of inactivation both in the presence and in the absence of choline. Nickel, cobalt, and iron salts not only increase the rate of inactivation, but also combine reversibly with a group on the enzyme to inhibit it. Manganese salts have no effect in comparable concentrations. The specificity of these effects is described.

PAGE, Cleveland.

FREE γ-AMINOBUTYRIC ACID IN BRAIN. J. AWAPARA, A. J. LANDUA, R. FUERST, and B. SEALE, J. Biol. Chem. **187**:35, 1950.

The presence of free γ-aminobutyric acid has been established chromatographically. Proof of its identity was provided by isolation of the compound and by the silver salt. Analysis of the latter showed close correlation with the calculated values. The probable origin of γ-aminobutyric acid was investigated. The data showed that glutamic acid is converted into γ-aminobutyric acid by decarboxylation.

PAGE, Cleveland.

γ-AMINOBUTYRIC ACID IN BRAIN: ITS FORMATION FROM GLUTAMIC ACID. E. ROBERTS and S. FRANKEL, J. Biol. Chem. **187**:55, 1950.

γ-Aminobutyric acid has been shown to be a constituent of brain, in which it exists preponderantly in the free form. Experiments with various crude enzyme preparations from mouse brain showed a net increase of γ-aminobutyric acid, which was accelerated by the addition of glutamic acid. It was shown by the use of isotopically labeled glutamic acid that the latter amino acid can serve as a precursor for the γ-aminobutyric acid. It is suggested that the formation of this compound in brain takes place by the α decarboxylation of glutamic acid.

PAGE, Cleveland.

IDENTIFICATION OF γ-AMINOBUTYRIC ACID IN BRAIN BY THE ISOTOPE DERIVATIVE METHOD. S. UDENFRIEND, J. Biol. Chem. **187**:65, 1950.

Paper chromatography in conjunction with the two isotope techniques of labeling, as in the method with isotope-derivative indicator, may be used as a rigorous method for chemical identification at the microgram level. The γ-aminobutyric acid has been identified in extracts of mouse brain.

PAGE, Cleveland.

DECARBOXYLATION OF L-GLUTAMIC ACID BY BRAIN. W. J. WINGO and J. AWAPARA, J. Biol. Chem. **187**:267, 1950.

The metabolism of *l*-glutamic acid in brain has been of interest, since it is the only amino acid capable of maintaining respiration of brain. Recently, Awapara and associates and, independently, Roberts and Frankel reported the presence of significant amounts of free γ-aminobutyric acid in the brain of several animal species. This amino acid is known to be formed in bacteria and in some plants by the decarboxylation of glutamic acid. This reaction, however, has never been reported to occur in tissues of higher forms of life. The decarboxylation of cysteic acid and dopa (dihydroxyphenylalanine) has now been established with certainty. Preliminary experiments indicated that γ-aminobutyric acid was formed on incubation of glutamic acid with rat-brain homogenates. The results reported here show that a decarboxylation occurs, as indicated by the production of carbon dioxide under anaerobic conditions, and the parallel increase in γ-aminobutyric acid, as shown by means of filter-paper chromatography. The enzyme glutamic-acid decarboxylase can be demonstrated in brain. In rat brain it has a optimum pH of 6.8 and a Michaelis constant of 0.021 M. It is active in homogenates for two hours and is inhibited by cyanide, semicarbazide, and hydroxylamine, but not by octyl alcohol. It is not active toward aspartic acid but is inhibited by aspartic acid in fairly large concentrates.

PAGE, Cleveland.

EFFECTS OF INDUCED FEVER ON CEREBRAL FUNCTIONS IN NEUROSYPHILIS. A. HEYMAN, J. L. PATTERSON JR., and F. J. NICHOLS JR., J. Clin. Invest. **29**:1335 (Oct.) 1950.

Although fever is known to be associated with definite alterations in the circulation and metabolism of the body as a whole and of certain individual organs, there have been few

observations on the changes occurring in the brain. This report presents studies on the effects of induced fever on the cerebral circulation and oxygen consumption in 27 patients with neurosyphilis.

Fever was induced by typhoid bacterial pyrogen or malaria in 13 patients with asymptomatic neurosyphilis and 14 patients with dementia paralytica. The effects on the cerebral blood flow and cerebral oxygen consumption were determined.

Patients with asymptomatic neurosyphilis had a normal cerebral blood flow and cerebral oxygen consumption in the afebrile state and showed only minimal changes during fever. Patients with dementia paralytica, however, showed values for the cerebral blood flow and oxygen consumption which were abnormally low in the afebrile state but which increased on the average by 30 and 24%, respectively, during fever.

The authors point out that it is apparent that the brain in asymptomatic neurosyphilis does not share in the increases in cardiac output and total body metabolism which are known to occur during fever. They make the tentative assumption that the normal brain has a response to fever similar to that of patients with asymptomatic neurosyphilis. The possibility that the beneficial effects of fever therapy in dementia paralytica are in part related to the increase in cerebral blood flow is discussed.

ALPERS, Philadelphia.

CORTICO-CORTICAL CONNECTIONS OF THE CORTEX BURIED IN THE INTRAPARIETAL AND PRINCIPAL SULCI OF THE MONKEY (MACACA MULATTA). O. SUGAR, R. PETER, L. V. ARADOR, and B. GRIPONISSIOTIS, J. Neuropath. & Exper. Neurol. **9**:430 (Oct.) 1950.

Among the primary fissures in the brain of the macaque monkey is the sulcus intraparietalis. It runs to the parieto-occipital notch from a point not far occipital to the central sulcus and not far dorsal to the Sylvian fissure, and thus lies within the parietal lobe. The sulcus principalis, however, is a secondary sulcus, lying in the frontal lobe between the two limbs of the arcuate sulcus. The existence of long pathways between the general regions of these sulci has been known for some time. The probability of existence of connections involving the buried cortex of these sulci with one another and with other parts of the brain led Sugar and his associates to investigate the corticocortical connections of their banks.

Applying the methods of physiological neuronography, they found that, beside strong local firing, there appear to be long pathways from the inferior bank of the intraparietal sulcus to the occipital lobe (OA, OB, OC), to the frontal pole (FC, FD, FDO), especially near and in the sulcus principalis, and to the posterior portion of the first temporal gyrus (TA).

Long-distance firing was less intense from the superior bank of the intraparietal sulcus, except for moderate firing into the dorsal half of the precentral region. There was good firing to electrodes spanning the arcuate sulcus, but no firing of consequence to the tip of the frontal lobe (FD).

The posterior portion of the buried cortex in the sulcus principalis fired not only the frontal lobe but also the region along the intraparietal sulcus and the inferior parietal lobule. The anterior portion fired locally into the frontal lobe for the most part.

Firing from the sulcus principalis to the contralateral hemisphere was confined to the region in front of the arcuate sulcus. From the superior bank of the sulcus intraparietalis, firing was restricted into the corresponding region of the other side. From the inferior bank, however, contralateral firing was found into the inferior parietal lobule and also into the frontal tip.

ALPERS, Philadelphia.

CHRONIC FOCAL HYPER-IRRITABILITY OF SENSORY NERVOUS SYSTEM IN CATS. A. M. KENNARD, J. Neurophysiol. **13**:215 (May) 1950.

Chronic focal hyperirritability of sensory cutaneous areas was produced in cats by application of alumina (aluminum oxide) cream above the dorsal aspect of the lumbar portion of the spinal cord. The hyperesthesia and hyperalgesia developed over a period of days to weeks. Once they became maximal they were permanent for at least nine months (the longest period of Kennard's observation).

The hyperirritable region developed first near the spinal segments at the site of injection and then spread to involve many segments in either direction. Light-touch, heavy-touch, and pain stimuli all became disagreeable, and apparently painful, to the animals over the affected areas. The light-touch stimulus seemed to be the most disturbing.

There was a hyperreflexia, but no other change in motor status. Proprioception was normal except in three instances, when it was affected for the first week after operation, probably as a result of operative trauma.

The condition which developed was similar in many ways to that seen when the same substance has been applied to the motor cortex, producing chronic recurrent epilepsy. In many respects it was like the causalgic state which is seen in man.

ALPERS, Philadelphia.

VISUAL AREAS I AND II OF CEREBRAL CORTEX OF RABBIT. J. M. THOMPSON, C. N. WOOLSEY and S. A. TALBOT, J. Neurophysiol. **13**:277 (July) 1950.

The cortical area of the rabbit which responds with typical surface-positive waves to gross contralateral photic stimulation extends about 15 mm. anterior to the occipital margin of the hemisphere. Its medial border is at the splenial sulcus, or 1 to 2 mm. medial to the sulcus, and its lateral border is about halfway down the lateral surface of the brain. The portion of the visual area which responds to gross ipsilateral photic stimulation is in the form of a band extending diagonally from the anteromedial to the posterolateral portion of the visual area.

The vertical meridian for binocular vision is situated 20 degrees from the sagittal plane of the visual field of the deeply anesthetized animal, and when projected on the cortex it divides the binocular area into approximately equal parts. On localized photic stimulation the visual area anterolateral to this line shows a pattern resembling a mirror image, on a smaller scale, of the visual area which lies posteromedial to this line. The authors have designated the larger posteromedial area visual area I and the smaller anterolateral area visual area II.

The horizontal meridian projects close to the posterior edge of the dorsal surface of the cerebrum except for a decided anteromedial dip along the vertical meridian for binocular vision. The upper visual field is represented to about 15 degrees above the horizontal meridian, and the lower visual field, to more than 20 degrees. The lateral visual field has been found to be represented to more than 150 degrees from the sagittal plane in both visual area I and visual area II. The responses obtained from visual areas I and II, with the animal under deep anesthesia, were similar in form, amplitude, and latency.

ALPERS, Philadelphia.

EFFECT OF SECTION OF VESTIBULAR NERVE UPON CORTICALLY INDUCED MOVEMENT IN CAT. W. H. KEMPINSKY and A. A. WARD JR., J. Neurophysiol. **13**:295 (July) 1950.

The effect of vestibular-nerve section on a cortically induced motor response was studied in the cat. It was found that with use of near-threshold stimulation of the motor cortex, the motor response in a limb was greatly diminished or abolished after section of either eighth cranial nerve.

The authors conclude that the vestibular nerve contributes afferent impulses which maintain a certain background activity in some part of the facilitatory system. After section of the vestibular nerve, it appears that such reverberative activity requires a measurable length of time to die out. Furthermore, markedly increasing the strength of cortical stimulation may mask or compensate for this effect in the static animal.

ALPERS, Philadelphia.

HYPOTHALAMO-HYPOPHYSIAL CONNEXIONS IN THE CETACEA. G. W. HARRIS, J. Physiol. **3**:361, 1950.

The pituitary glands of four adult and four fetal whales have been examined with particular regard to the anatomical structures connecting the tuber cinereum and the pars distalis.

The pars tuberalis extends upward anterior to the thick septum which separates the infundibular process and the pars distalis and enfolds the tuber cinereum in the way usual in other mammals. The region where the pars tuberalis merges with the pars distalis bears many points

of similarity to the zona tuberalis of the rabbit, and the term zona tuberalis is applied to this region of the cetacean gland.

Nerve fibers were not seen in the pars distalis, though the presence of a rich reticular-fiber framework was verified.

A prominent system of hypophysial portal vessels is associated with the pars tuberalis, linking the median eminence of the tuber cinereum and the pars distalis.

THOMAS, Philadelphia.

ACETYLCHOLINE SYNTHESIS IN NORMAL AND DENERVATED SYMPATHETIC GANGLIA OF THE CAT. JEAN BANISTER and MARIAN SCRASE, J. Physiol. **3**:437, 1950.

A method is described for measuring acetylcholine synthesis in individual nerve ganglia in the cat. Superior cervical, stellate, celiac, and nodose ganglia were tested for choline acetylase activity by this method.

The highest figures for acetylcholine synthesis were obtained from normal superior cervical and stellate ganglia. These averaged about 8 γ of acetylcholine per ganglion per hour; expressed conventionally, this figure represents 3 mg. of acetylcholine per gram of acetone-dried powder per hour. In 30% of ganglia 4 mg. of acetylcholine per gram of powder per hour or more was obtained.

The synthesis of acetylcholine by denervated ganglia was also measured. About 40 hours after denervation of a ganglion, at a time when impulse transmission was usually impaired, the choline acetylase activity of the ganglion was only about 40% of the value for the control side. About 90 hours after denervation synthesis was less than 20% of that on the normal side.

THOMAS, Philadelphia.

Neuropathology

CHANGES IN THE ARTERIAE NERVORUM IN PERIPHERAL NERVE INJURIES IN MAN. B. WOODHALL, and C. DAVIS JR., J. Neuropath. & Exper. **9**:335 (July) 1950.

Bacsich and Wyburn have shown that in the sciatic nerve of the rabbit there is no significant difference between the vascular patterns of unmobilized and those of fully mobilized nerves, or any evidence of a quantitative diminution in circulation after severance of the regional nutrient arteries. If both nutrient and longitudinal vessels were obliterated, there was early evidence of ischemia in the distal nerve segment, followed by return to a normal pattern 14 days after the initial crush injury. After a similar derangement of the nerve of this rabbit they encountered no notable variation from the normal in axonal regeneration up to 30 days after operation. They concluded that, since the blood-vessel pattern of the rabbit's sciatic nerve resembled that of the human sciatic nerve, the neurosurgeon might view dispassionately any necessary vascular interference within the range of necessary surgical procedures in man.

In view of the aforementioned studies in the experimental animal, it appeared desirable to visualize changes that develop in the arteriae nervorum of human nerves that have been subjected to traumatic severance. With a knowledge of these preexisting structural alterations, together with anatomic and physiologic data, the neurosurgeon should be better prepared as he contemplates nerve segment.

Woodhall and Davis found that the intrinsic blood vessels of human peripheral nerves show a series of structural and quantitative alterations as the result of injury. These changes include acute thrombosis, intimal proliferation, recanalization of occluded vessels, and a variation in actual number of arterioles of the epineurium and interfascicular space. The smaller vessels of the perineurium and the endoneural space show thickening of their walls with obliteration of the vascular channel. In certain cases these precapillary arterioles and capillaries may become vastly more numerous. In general, these changes are more striking in the distal nerve segment and thus may be considered the direct sequel of interference with the longitudinally oriented vascular system. Some may be related to specific factors, such as traction, to an advantageous time interval after injury, or to their relation to the zone of nerve contusion. In ischemia there appears to be adequate histologic evidence that occlusion of the major longitudinal vessels and their nutrient lateral vessels may lead to an excessive deposition of collagen in the distal segment. This fundamental disturbance is poorly understood.

Although the exact relation between blood supply and endoneural fibrosis is not immediately apparent, it is evident from this study that in many cases of human peripheral-nerve injury the vascular supply of the distal nerve segment is impaired, if not in critical balance, at the time of definitive operative intervention. Excessive mobilization of nerve segments, in particular the distal segment, with injudicious sacrifice of remaining lateral nutrient vessels, may initiate intraneural changes compatible with those described in ischemia. The neurosurgical problem cannot be dismissed, at least by comparison with acute lesions in the experimental animal.

ALPERS, Philadelphia.

GROSS MORBID ANATOMY OF THE CENTRAL NERVOUS SYSTEM OF CASES OF TUBERCULOUS MENINGITIS TREATED WITH STREPTOMYCIN. P. M. DANIEL, Proc. Roy. Soc. Med. **42**:169 (March) 1949.

The main difference between streptomycin-treated and untreated tuberculous meningitis is apparently due to prolongation, slowing down, or even regression and healing of the disease process. The thick, greenish-yellow exudate at the base of the brain is regarded by the author as significant from two standpoints: its interference with the circulation of the cerebrospinal fluid and its influence on the blood vessels, especially the arteries. By extension of the main subarachnoid lake at the base of the brain, all the major cerebral arteries, and, what is more important, their small branches can be bathed with exudate. The exudate is of wooden-hard, rather than gelatinous, consistency in those cases in which life has been prolonged by streptomycin, and is usually thicker. In the arteries embedded in the tuberculous exudate there commonly develops an arteritis, which, with the subsequent diminution or occlusion of the lumen, presents the most serious consequence of the basal exudate. This exudate often presents as a thick collar around the midbrain. The hypothalamic symptoms noted clinically may be due to interference with the blood supply in this region. An encephalitis in the depths of the sulci is frequently seen, as well as granulomas of varying size and activity. The vital importance of early diagnosis and treatment lies in the prevention or diminution of the basal exudate.

In the discussion, Dr. I. A. B. Cathie commented on the clinical pathology, noting that without meningitis streptomycin from the blood stream penetrates with difficulty to the cerebrospinal fluid, but that with meningeal inflammation the blood-brain barrier is more easily passed. When the drug is given intrathecally, there appears to be no penetration into the substance of the brain. In the normal thecal space there occurs an immediate polymorphonuclear-cell response to streptomycin, and clinically the antibiotic is poorly tolerated when there is no meningeal inflammation. The cell count and protein content of the fluid vary considerably from day to day on a regimen of daily intrathecal injections. The sugar content of the cerebrospinal fluid is low, returning to normal with recovery but lagging behind the return of cell and protein levels. The continued presence of tubercle bacilli long after the treatment is started is considered a bad prognostic sign, and when the organisms persist tuberculomas of the meninges are commonly found. The likelihood of reinfection is present because the avascularity of the lesion will not permit penetration of the streptomycin. In an effort to attack the fibrinous exudate, fibrinolysin from hemolytic streptococci has been used, with encouraging results.

BERRY, Bethesda, Md.

SYPHILITIC ENDARTERITIS OF THE SMALL VESSELS OF THE CEREBRAL CORTEX: REPORT OF A CASE. RICHARD KRYSPIN-EXNER, Wien. klin. Wchnschr. **61**:345 (June 3) 1949.

A woman aged 58 was bedridden, incontinent, restless, negativistic, and disoriented. She was mildly dysarthric; the pupils reacted sluggishly to light but promptly in accommodation. A Babinski sign was elicited on the right side. The spinal fluid showed a strong reaction for globulin with 293 cells per cubic millimeter. The Wassermann reactions of the blood and spinal fluid were negative. Postmortem examination substantiated the diagnosis of syphilitic endarteritis of the small cortical vessels (Nissl-Alzheimer sclerosis).

This rare condition is characterized by a marked proliferation of the endothelium and adventitia of the small cortical vessels, as well as of the medium and small pial vessels. Foci of softening related to vascular changes are observed. Syphilitic meningitis may also be present. Spirochetes are usually not demonstrable.

MASON, New York.

Meninges and Blood Vessels

STREPTOCOCCUS VIRIDANS MENINGITIS: A REVIEW OF THE LITERATURE AND REPORT OF NINE RECOVERIES. A. L. HOYNE and H. HERZON, Ann. Int. Med. **33**:879 (Oct.) 1950.

Twenty-five recoveries and 26 deaths have been reported in the literature concerning meningitis produced by the green-producing Streptococcus ("Streptococcus-viridans meningitis"). To these the authors add 9 recoveries and 3 deaths, making a total of 34 recoveries and 29 known deaths. Six cases, including two with recovery from the wards of Cook County Hospital, are also included in the tables of this article.

The incidence of Str.-viridans meningitis was found to be from 0.3 to 2.4% of all cases of purulent meningitis. The frequency of streptococcic meningitis of all types has decreased in the past five years. This may be a result of the decline of severe ear, nose, and throat infections and is often attributed to the use of the sulfonamides and antibiotics. Cases of Str.-viridans meningitis have shown a relative increase, as compared with the total number of cases of all types of streptococcic meningitis.

The probable sources of infection in Str.-viridans meningitis are analyzed. The disease followed subacute bacterial endocarditis in only 13% of the cases, and ear, nose, and throat infections in 31%; no source was found (primary) in 35%.

Green-producing streptococci have been found to vary in their sensitivity to different sulfonamides and to penicillin. In addition, some strains are resistant to either the various sulfonamides or to penicillin. There were no reports that any one strain was resistant to both the sulfonamides and penicillin.

The authors point out that therapy of Str.-viridans meningitis should be adjusted after determination of the sensitivity of the organism isolated from the spinal fluid to all the sulfonamides and to the antibiotics. When sensitivity tests are not available, and prior to learning the results of these tests, the treatment of choice appears to be the use of a combination of penicillin and a sulfonamide. Penicillin should be given in large doses intramuscularly. Intrathecal medication is contraindicated and repeated spinal punctures are seldom necessary. The sulfonamide should be given in a dose of 2 to 3 grains (0.130 to 0.195 gm.) per pound of body weight per day and may be sulfathiazole, sulfadiazine, or sulfapyridine.

ALPERS, Philadelphia.

ACUTE VASCULAR CRISIS AFTER SYMPATHECTOMY. F. MANDL, Wien. klin. Wchnschr. **61**:449 (July 22) 1949.

Mandl reports on two cases of peripheral vascular sclerosis for which lumbar ganglionectomy was performed. Gangrene developed a few days after operation in the first case and four weeks after it in the second case. The author believes that vasodilatation in one vascular territory may be followed by withdrawal of a sufficient amount of blood from another vascular bed to produce gangrene. Temperature tests, especially those after hyperemia of the upper extremities has been produced, are held to be of great prognostic value when sympathectomy is contemplated.

MASON, New York.

Diseases of the Brain

DISSEMINATED LUPUS ERYTHEMATOSUS WITH SYDENHAM'S CHOREA AND RHEUMATIC HEART DISEASES: CASE WITH AUTOPSY. F. K. BAUER, W. C. RILEY, and E. B. COHEN, Ann. Int. Med. **33**:1042 (Oct.) 1950.

It has been well established in recent years that both rheumatic fever and disseminated lupus erythematosus are systemic disease entities characterized by lesions involving certain peripheral and central vascular fields. The lesions are similar to those produced in experimental anaphylaxis. Chorea is considered a manifestation of rheumatic fever. So far, Sydenham's chorea has not been observed in association with disseminated lupus erythematosus.

The case here reported is one of the typical pictures of Sydenham's chorea in a Negro girl aged 16 with a history of "rheumatic" disease, uneventful and characteristic recovery from the choreic manifestations after one month's hospitalization, and the subsequent appearance, six

weeks later, of the characteristic clinical picture of disseminated lupus erythematosus. There was clinical evidence of carditis.

The drugs administered during the patient's stay for chorea, and during her second admission, were salicylates, ascorbic acid, penicillin, and tripelennamine ("pyribenzamine").

The patient's course was steadily downhill, and she died five months after her second admission. At autopsy, both rheumatic heart disease and disseminated lupus erythematosus were demonstrated. Study of the brain revealed proliferation of the intima of the small blood vessels. The blood vessels of the brain appeared to be thicker-walled than usual. Infarctions were found in the cortex and lenticular nuclei, with occlusion of vessels by thrombi. "In certain areas" was observed "an acute inflammatory condition," with leucocytes around many of the regional vessels. There was also associated softening of the gray matter of the lenticular nucleus.

The authors raise the question as to whether rheumatic fever and disseminated lupus erythematosus are to be considered different clinical manifestations of a hyperergic state.

ALPERS, Philadelphia.

FEBRILE CONVULSIONS IN CHILDREN. M. G. PETERMAN, J. A. M. A. **143**:728 (June 24) 1950.

A febrile convulsion may be distinguished from the other convulsions associated with acute infection by the arbitrary definition of a major seizure associated with a rapid rise in temperature to a certain level, specific for each child. The fever usually precedes and precipitates the seizure. Peterman reviewed 3,000 cases of convulsions in his experience and selected 128 cases from those classified under "acute infection" which might be designated as cases of febrile convulsions according to this definition.

The high percentage of family histories of convulsions, abnormal electroencephalograms, and the subsequent development of epilepsy indicates that the convulsive disorder is inherited.

Every convulsion in childhood demands a thorough study, including an electroencephalographic recording and an attempt to make a diagnosis. This is necessary as a guide to treatment.

The immediate treatment in the febrile convulsion must be the reduction of the fever. However, the next problem, of equal importance and urgency, is the establishment of the diagnosis, as the basis for further treatment and prevention of recurrence. After that, the drug of choice is phenobarbital, phethenylate (thiantoin®), "gemonil" (5, 5-diethyl-1-methyl barbituric acid), phenacemide (phenurone®), or diphenylhydantoin (dilantin®) sodium, depending on the diagnosis. The treatment must be continued at least one year after the last convulsion and after the electroencephalogram becomes normal.

ALPERS, Philadelphia.

UREMIA ENCEPHALITIS. F. Y. TICHY, J. Neuropath. & Exper. Neurol. **9**:344 (July) 1950.

Tichy reports a case of encephalopathy due to uremia in which there was an unusually severe involvement of the perivascular myelin of the cerebrum with minimal alterations of their structures. The changes are similar to those of other toxic encephalitides and of multiple sclerosis and indicate that a primary vascular genesis is improbable.

ALPERS, Philadelphia.

MENINGIOMAS OF THE CEREBELLOPONTINE ANGLE. G. BAKER and L. A. CHRISTOFERSON, Proc. Staff Meet., Mayo Clin. **25**:549 (Sept. 13) 1950.

Although meningiomas are usually benign tumors, the proximity of vital centers within the brain stem and pons makes their complete removal from the cerebellopontie angle extremely difficult and hazardous. In addition, in order to effect removal from this location, it is usually necessary to sacrifice one or more cranial nerves. The case here reported, that of a woman aged 44, was an exception.

Diagnostically, the patient presented an interesting situation because of the emphasis placed on dysphagia and dysarthria, and because she did not suffer from headache and presented no signs of involvement of the fifth cranial nerve. Therapeutically, her case was even more interesting, not only because the tumor was removed without visible damage to the brain or cranial nerves but also because the function of the involved cranial nerves was improved. The left acoustic

nerve had not functioned for over two years, and yet the hearing returned completely after total removal of the meningioma.

ALPERS, Philadelphia.

UNILATERAL EXOPHTHALMOS FROM ORBITAL MALFORMATION IN RECKLINGHAUSEN'S DISEASE. D. PETIT-DUTAILLIS, M. FELD, and J. TAPTAS, Rev. neurol. **81**:203 (March) 1949.

Except for exophthalmos of sympathicotonic origin, unilateral exophthalmos usually poses the problem of a retro-orbital space-occupying lesion. The authors report two cases of Recklinghausen's disease (neurofibromatosis) in which defective ossification of the wall of the orbit allowed intracranial pressure to be transmitted to the orbit, causing unilateral exophthalmos. The exophthalmos appeared in childhood in both cases. Roentgenograms demonstrated general enlargement of the orbit with absence of bony landmarks in the posterior wall. On lateral view, as a result of failure of ossification of the optic canal, an omega-shaped enlargement of the sella turcica was apparent; this led to retro-orbital exploration, with negative results, in both cases.

In one case there were no neurologic signs except for exophthalmos, but the patient had amenorrhea and scanty pubic and axillary hair at the age of 20. In the other case there was left hemiparesis in addition to the right exophthalmos, but this was due to a parasagittal meningioma, which was removed at operation subsequent to the negative frontotemporal exploration.

The authors note that bony malformation has been reported before as a concomitant lesion of Recklinghausen's disease; its importance lies in its leading to an erroneous diagnosis of intracranial neoplasm.

LEGAULT, Washington, D. C.

HEADACHE DUE TO CHRONIC CARBON-MONOXIDE INTOXICATION. JULIO A. GHERSI, Prensa méd. argent. **37**:446 (March 3) 1950.

Ghersi points out the probable frequency of headache due to exposure to carbon monoxide. This exposure is often a result of heating with inadequate ventilation and cooking in poorly ventilated quarters. Chronic headaches in each member of a family of five are reported. The headaches disappeared after adequate prophylaxis against exposure to carbon monoxide.

N. SAVITSKY, New York.

HYPERTENSIVE ENCEPHALOPATHY ASSOCIATED WITH HYPOCHLOREMIA. T. HILDEN, Acta med. Scandinav. **136**:199, 1950.

Hilden observed five patients with acute cerebral disturbances, hypertension, a transient fall in plasma chlorides, and an increase in blood urea. Plasma-chloride and blood-urea values should be investigated in all cases of acute encephalopathy. The relation of electrolytic disturbance to cerebral symptoms is of particular interest because of a salt-poor diet widely used in the treatment of hypertension. The restriction of sodium chloride may result in hypochloremia and an increase in blood urea, causing cerebral symptoms, or even death. Three of the five patients were treated by parenteral administration of isotonic sodium-chloride solution, with apparently some improvement.

J. A. M. A.

Peripheral and Cranial Nerves

RELATION BETWEEN NEURITIS AND THE CLINICAL BACKGROUND IN DIABETES MELLITUS. A. BONKALO, Arch. Int. Med. **85**:944 (June) 1950.

Bonkalo analyzed a homogeneous series of 150 cases of diabetes under uniform conditions in order to find out how closely factors in a diabetic background were connected with the development and maintenance of neuritis. In 74 cases (49.3%) objective symptoms of diabetic neuritis were noted, whereas no neuritic involvement was found in the remaining 76 cases. An attempt was made to establish a relation between the diabetic neuritis, on the one hand, and the blood-sugar level, ketone-body excretion, and body habitus, on the other. The author found a relation between the blood-sugar content and the neuritis in that, on the average, the patients with neuritic involvement had a higher blood-sugar level than those without neuro-

pathy. Ketone-body excretion had no connection with these findings. The incidence of diabetic neuritis appears to be higher in young patients with an obese and dysplastic habitus.

ALPERS, Philadelphia.

PATHOGENESIS AND NOSOLOGY OF THE SO-CALLED GUILLAIN-BARRÉ SYNDROME. T. GEREB, Wien. klin. Wchnschr. **61**:263 (June 10) 1949.

Gereb reports eight cases in which the Guillain-Barré syndrome followed various infectious illnesses and concludes that the syndrome does not represent a specific entity. It may follow various infections, or more rarely toxic conditions, as an ordinary polyneuritis. The author explains the albuminocytologic dissociation, not as an allergic serous reaction of the meninges, but as a mechanical obstruction of the spinal veins by the inflamed and edematous spinal roots.

MASON, New York.

Treatment, Neurosurgery

PREVENTION OF MIGRAINE ATTACKS BY DILANTIN SODIUM. L. G. ROWNTREE and R. W. WAGGONER, Dis. Nerv. System **11**:148 (May) 1950.

Diphenylhydantoin, taken regularly in adequate doses, staves off migraine attacks in many sufferers from that disease. The authors advise concomitant avoidance of allergic substances known to have precipitated previous headaches. In a cited case, a woman in her early sixties, who had suffered from devastating migraine since the age of 50 without any response to standard medications, was relieved by diphenylhydantoin, 0.1 gm., given three times a day. In five years she has had only two attacks, one during an attempt to abandon the drug. The rationale of this treatment derives from the fact that many persons with a paroxysmal-headache syndrome have abnormal electroencephalograms resembling grand-mal tracings. With such findings, the benefit from diphenlhydantoin is almost uniform. When electroencephalography is not available, the drug may properly be used on a trial basis.

BEATON, Tucson, Ariz.

RUPTURE OF THE RECTUS ABDOMINIS MUSCLE FOLLOWING ELECTROSHOCK THERAPY. N. SAVITSKY and W. KARLINER, J. A. M. A. **143**:431 (June 3) 1950.

A white woman aged 51 had had a number of courses of electroshock therapy over a period of 10 years for a schizophrenic-like syndrome. The past history included arterial hypertension, influenza 30 years before, a severe attack of polyarthritis five years later, and removal of the right kidney nine years previously.

Five hours after an ambulatory electroshock treatment with a typical grand-mal response of about one-minute's duration, the patient complained of severe abdominal pain in the right lower quadrant. The abdominal tenderness and rigidity, as well as a leucocyte count of 16,000, with a shift to the left, suggested the diagnosis of acute appendicitis. At operation the right rectus muscle was found torn near its inferior end, and there was about a pint (500 cc.) of blood in the preperitoneal area. After careful control of bleeding points, the wound was closed, and the patient made a rapid and uneventful recovery. Three weeks after the operation the patient's paranoid trends again became pronounced. Curare was then given prior to each electroshock treatment. Since then the patient has been treated intermittently during exacerbations of psychotic behavior without ill effects.

ALPERS, Philadelphia.

AUREOMYCIN IN THE TREATMENT OF POLIOMYELITIS. E. APPELBAUM and R. SAIGH, J. A. M. A. **143**:538 (June 10) 1950.

Thirty-eight patients with nonparalytic poliomyelitis were treated with aureomycin during the early phase of the disease, while 66 patients who did not receive the drug served as controls. The aureomycin-treated patients and the controls were admitted during the same period and were similar in all essential respects. The clinical results were about the same in the treated and in the control patients. The development of paralysis in two of the treated patients but in none of the controls was regarded as fortuitous.

In this study the use of aureomycin early in the disease did not appear to affect favorably the clinical course of poliomyelitis.

ALPERS, Philadelphia.

STREPTOMYCIN IN THE TREATMENT OF INFLUENZAL MENINGITIS: A STUDY OF NINETY CASES, WITH 96.6 PER CENT RECOVERY. E. APPELBAUM and J. NELSON, J. A. M. A. **143**:715 (June 24) 1950.

In 90 consecutive cases of meningitis due to Hemophilus influenzae, streptomycin was given intramuscularly and intrathecally in 73 and intramuscularly only in 17. In addition, sulfadiazine was used in all but one of the cases, and the specific rabbit serum was administered in 17 cases and aureomycin in one case. Of the 90 patients, 87 recovered and 3 died, a recovery rate of 96.6. The 17 patients treated with intramuscular, but without intraspinal, injections of streptomycin recovered completely.

With regard to adjunctive therapy, it was difficult to evaluate the role of sulfadiazine. There was no evidence that rabbit serum played a contributory role.

There were relatively few toxic reactions in the series, and neurological residua occurred in a small number of cases.

ALPERS, Philadelphia.

TREATMENT OF CHOICE IN BARBITURATE POISONING: SERIES OF TWENTY-NINE CASES OF BARBITURATE POISONING TREATED WITH PENTYLENETETRAZOLE (METRAZOL®) AND SUPPORTIVE THERAPY. A. W. JONES, J. DOOLEY and J. R. MURPHY, J. A. M. A. **143**:884 (July 8) 1950.

The authors report a review of 29 cases of barbiturate poisoning. For the purpose of evaluating therapy, they divided the cases into two major groups. In the first group were patients in a critically deep stage of anesthesia, having no reflexes on admission; in the second group were patients who were in coma but in a light state of anesthesia, having corneal and other reflexes when first examined.

Supportive therapy plays a prominent role, as does early and adequate treatment of complications. Lavage is contraindicated in the course of treatment unless a patient is fully conscious; otherwise, hypostatic pneumonia is likely to occur. Intravenous injection of fluids, used too vigorously, puts an added strain on the cardiovascular system and is to be deplored. However, it is a useful adjunct to elimination of the barbiturate when it is properly used.

Jones and his co-workers found that pentylenetetrazole (metrazol®) is a relatively safe drug to use in large quantities and may prevent many deaths as a result of poisoning with barbituric acid derivatives if so used. Further, it can be used by any physician anywhere for immediate relief until the patient can be transported safely to a hospital, where further treatment can be instituted. The authors used pentylenetetrazole in large doses as the analeptic of choice in 17 of 29 cases of barbiturate poisoning; there were no deaths due solely to drugs.

ALPERS, Philadelphia.

INTERMITTENT TREATMENT OF POLIOMYELITIS WITH PROGRESSIVE RESISTANCE EXERCISE. S. MEAD, J. A. M. A. **144**:458 (Oct. 7) 1950.

The physiologic basis for progressive resistance exercise is the well-demonstrated fact that muscle cells respond to overload exercise by hypertrophy increase in size, not in the number of contractile units. This increase in size is accompanied by increase in work capacity.

When a muscle has been totally denervated as a result of poliomyelitis, treatment of any type directed at the muscle itself is irrational. Progressive resistance exercise is therefore directed at partially denervated muscles. In a muscle that has been, for example, about 50% denervated, the purpose of progressive resistance exercise is to induce hypertrophy and raise contractile power to perhaps 70 or 80% of its original strength. There are definite anatomic limits beyond which this process will not go.

Mead has used the DeLorme table and technique for a group of 50 patients. Progressive resistance exercises were begun as soon as the patient was out of isolation (in three weeks). Pain and tenderness were treated symptomatically; shortening reactions, by gentle stretching. Splints, corsets, and bracing were used freely to prevent deformity and to insure early walking. In no instance did early active exercise result in further paralysis or appear to harm the patient

in any way. A few weeks of intensive daily exercise was alternated with three or four months of home activities, until no further improvement occurred.

The advantages of this regimen over continuous treatment include economy of effort and means, more efficient use of equipment and personnel, and better psychologic adjustment. Most important is the quantitative measure of progress provided.

ALPERS, Philadelphia.

EFFECT OF STREPTOMYCIN ON TUBERCULOUS MENINGITIS. A. LEVINSON, J. A. LUHAN, W. P. MAVRELIS, and H. HERZON, J. Neuropath. & Exper. Neurol. **9**:406 (Oct.) 1950.

In this investigation, the authors studied the pathologic picture in tuberculous meningitis and the associated generalized miliary tuberculosis in 26 cases in which streptomycin was therapeutically employed.

Thirty-eight infants and children were treated. Seven of the patients made apparent recoveries, with complicating hemiparesis in one and deafness in two. The longest survival period to date is two and one-half years, the patient being still alive.

Of the 38 cases in the series, necropsy was performed in 23; with the addition of three others (two of adults), these form the basis of the present study. Treatment consisted of intramuscular administration of streptomycin, usually 0.2 gm. every three hours. No intrathecal therapy was given, except to the first patient, who received nine intraspinal injections, and to two patients who had received previous treatment at other hospitals, including 23 and 24 intrathecal injections, respectively. Treatment was continued for at least 90 days unless the patient did not live that long; in addition, if a relapse occurred, further treatment with streptomycin was given, until death.

This report is an analysis of the pathologic findings in 16 cases in which life was prolonged a minimum of 35 days, with a study of 10 additional cases in which death occurred within 30 days of onset in order that the early effects of streptomycin treatment might be determined.

After prolonged therapy (a minimum of 90 days) changes associated with advanced healing were observed in the miliary lesions in the viscera and in the exudate of the meninges. Notwithstanding, there were usually present caseous or incompletely healed miliary foci and similar unhealed foci in the meninges.

The mechanism of healing of tuberculous lesions in the meninges and viscera was found to be a process of diminishing cellularity and progressive fibroplasia. Frequent features of the brain in these cases of streptomycin-treated meningitis were (1) ischemic or necrotic softenings in the rostral basal ganglia on the side opposite the hemiparesis (31%); (2) a greater incidence of high degrees of internal hydrocephalus than had been observed in cases of the untreated disease; (3) selective involvement of the stem of the Sylvian fissure with a thick granulomatous exudate, within which occurred endarteritis of branches of the middle cerebral artery supplying the basal ganglia, the cause of the ischemic softenings.

The mechanism of healing of the exudate, by the formation of a thick fibrous scar at the base of the brain, associated with endarteritis of arteries traversing the exudate, stands as an obstacle to uncomplicated recovery in streptomycin-treated tuberculous meningitis.

The most important clinical problem in the treatment of tuberculous meningitis is that of "relapse." Relapse in cases of streptomycin-treated tuberculous meningitis is here explained as resulting usually from a repeated miliary dissemination to the meninges from unhealed caseous foci in the body and occasionally from local breakdown of minute caseous foci within the meninges.

Levinson and his co-workers believe that intrathecal therapy is generally not necessary in cases of tuberculous meningitis. They feel that the present pathologic report adequately demonstrates that healing can be effected without resort to intrathecal therapy. The only two patients in this series receiving intensive intrathecal therapy (given at other hospitals) arrived in a moribund state.

ALPERS, Philadelphia.

SURGICAL TREATMENT OF SPONTANEOUS SUBARACHNOID HAEMORRHAGE: PRELIMINARY REPORT. MURRAY A. FALCONER, Brit. M. J. **1**:809 (April 8) 1950.

Falconer makes a preliminary report of the results obtained in the management of 40 consecutive patients with recent subarachnoid hemorrhage admitted to the Dunedin Hospital in

New Zealand during a 39-month period. The routine employed in the investigation and treatment of these patients consisted in (1) performance of carotid arteriography to locate and identify the lesion, followed immediately by (2) ligation of the common carotid artery on the appropriate side, and later, in some cases, by ligation of the internal carotid artery, and (3) subsequent direct attack on the aneurysm when accessible. In a few cases, as when the arteriograms indicated that the blood flow through the affected artery would not be affected appreciably by ligation, a direct attack was made without preliminary ligation.

There were 5 deaths; 26 patients were able to resume "their full lives without appreciable disability," and 5 additional patients, though disabled, were able to lead useful lives. Falconer believes that the mortality rate of 12.5% and the satisfactory-recovery rate of 65% obtained in this series, as compared with a mortality rate of 50 to 60% and a satisfactory-recovery rate of 16 to 30% obtained by conservative therapy, indicate that surgical measures have a place in the treatment of spontaneous subarachnoid hemorrhage, and one which he thinks will become routine. A case is reported of a patient with two aneurysms, one on each side of the circle of Willis, to illustrate the problems encountered in surgical treatment.

ECHOLS, New Orleans.

INTRASPINAL INJECTION OF TOXOID IN TREATMENT OF POSTDIPHTHERITIC PARALYSES. W. THIELE and S. PALM, Med. Klin. **45**:84, 1950.

Thiele and Palm observed that intravenous administration of toxoid exerted no influence on neurologic complications of diphtheria and failed to prevent the development of postdiphtheritic polyneuritis. Of 32 patients who, in addition to serum, were given intravenous injections of the toxoid, 11 had postdiphtheritic paralysis. Cremer observed favorable effects from intravenous injections of toxoid in muscular paralyses but not in purely neural lesions. For the latter he recommended intraspinal injections of toxoid in small doses (0.25 cc.) in order to avoid meningism. Thiele and Palm report five cases in which they studied the effects of intraspinal injections of the toxoid. Progressive disturbances in accommodation, swallowing, and the respiratory muscles, and other paralytic signs were the indications for the intraspinal administration of the toxoid. The favorable results obtained indicate the effectiveness of this treatment. There were no meningeal disturbances.

J. A. M. A.

SUCCESSFUL TREATMENT OF AMYOTROPHIC LATERAL SCLEROSIS: REPORT OF A CASE. LUISE LÖWE, Wien. klin. Wchnschr. **61**:365 (June 10) 1949.

In the case reported, the diagnosis of amyotrophic lateral sclerosis had been made four years previously and repeatedly confirmed by many prominent specialists from different countries. When she was first seen by the author, the patient's weight was down to 38 kg. (height, 170 cm.); her appetite was poor; she was dysphagic to the point of choking; there was paralysis of the tongue, her speech was toneless and incomprehensible, and muscular atrophies were present. There was marked lack of interest in her surroundings.

Physical therapy, consisting of galvanic and faradic stimulation, active and passive motion, and massage, was employed in order to maintain the circulation. Within a few weeks the patient was able to spend six to eight hours a day out of bed; the intake of food was improved, with a gain in weight of 1.5 kg. in the fourth week alone. The movements of the tongue improved; speech became audible, and some words were understandable; some of the atrophies seemed to recede, and her interest in her surroundings was awakened. The patient attended concerts and the opera. After six weeks of therapy she undertook a trip from London to Switzerland, and after eight weeks she made the overnight trip to Vienna in order to continue her treatment there.

MASON, New York.

PERMANENCY OF RESULTS OBTAINED BY SYMPATHETIC SURGERY IN TREATMENT OF PHANTOM PAIN. K. E. KALLIO, Acta orthop. Scandinav. **19**:327, 1949.

Kallio reports a follow-up study on 68 patients. He sent a questionnaire to all disabled soldiers who had been treated for phantom pain by sympathectomy in his hospital between one and four years previously. In 65 cases the pain was located in the phantom limb, and in six

of these it was felt simultaneously in the stump. In the remaining three the pain was felt only in the stump. In all cases in which the upper limb was affected infiltration of the stellate ganglion was first attempted several times, and sympathectomy was not performed if infiltration with procaine hydrochloride had been effective. Eight of the patients had undergone stellectomy; 34, lumbar sympathectomy, and 26, infiltration. In the majority of the patients (39) sympathectomy was found to have no effect, and in one patient it made the pain worse. In 29 patients the immediate results were good, but after one to four years only six patients reported that they were completely cured, and one said that the pain was less severe. The author believes that the value of sympathectomy in the treatment of phantom limb pain has been overestimated.

J. A. M. A.

Muscular System

MYASTHENIA GRAVIS IN A CHILD AGED FOUR AND A HALF YEARS. R. THIBAUDEAU, Laval méd. **15**:44 (Jan.) 1950.

Thibaudeau reports one case of myasthenia gravis in a boy aged 4½ years. There was sudden onset of the disease with unexplained fatigue. Ptosis of the upper eyelids was the first sign serving as a guide to the diagnosis. Within four months after the appearance of this sign the pseudoparalysis continued its course by involving the muscles of the face, of the extremities and of the trunk. Death resulted from cardiac failure during a myasthenic attack within six months after the onset of the disease. Death could not be prevented by the administration of large daily doses of 8 to 12 tablets of 15 mg. of neostigmine bromide by mouth and additional subcutaneous injections of 3½ ampuls of 1.5 mg. neostigmine methylsulfate per day. Roentgen irradiation of the thymus was performed several days before death to combat a presumed hypertrophy of the thymus. A degenerative inflammatory process in the thymus was demonstrated at necropsy.

J. A. M. A.

Society Transactions

BOSTON SOCIETY OF PSYCHIATRY AND NEUROLOGY

Donald J. MacPherson, M.D., Presiding
Regular Meeting, Feb. 15, 1951

Mental Disorder as a Mass Phenomenon: A Pattern for the Study of Minor and Major Disorders, as They Affect Populations of People, Based on an Epidemiologic Analysis of Suicide and Other Psychiatric Disease. DR. ERICH LINDEMANN, DR. JOHANNES IPSEN, DR. WARREN VAUGHAN JR., and DR. EDWARD O'ROURKE.

The panel of speakers presented a combined effort of epidemiologists and psychiatrists to apply epidemiological concepts and methods to the field of mental disease.

Dr. Gordon gave a brief description of the epidemiological frame of reference. The concern in this field is with disease as a mass phenomenon, rather than with clinical cases. The approach is by the study of different populations with respect to the incidence and prevalence of morbid conditions. Laboratory experiments are designed to elucidate the intimate interplay of agent, host, and environment in the prediction of disease.

There followed a series of illustrations describing movements of mental illness in population groups, and the distribution of mental illness in the time-place-person continuum was described. Point epidemics, seasonal variation, cyclic distribution, and endemic prevalence were illustrated by examples. Geographical differences relating to urban-rural differentiation and to states and nations were mentioned. The age distribution of multiple sclerosis and the sex distribution of hysteria were illustrated.

Dr. Lindemann then described the psychiatrist's point of view concerning the epidemiological method in mental disease, emphasizing that social scientists, being interested in social ecology and in the structure of the social system, would have to work with epidemiologists in ascertaining the pertinent factors in the human environment responsible for epidemiological variations.

The discussions then centered on the problem of suicide. The epidemiological approach to such a psychopathologic phenomenon requires assessment in terms not only of mortality but also of morbidity. The illness which leads to suicide as the fatal termination has to be studied. Dr. Lindemann then presented a picture of the biological gradient of the illness leading to suicide, which he named "hypereridism." He presented the concept of various levels of hostile tension, starting with normal anger and progressing through hostile inhibition to depression and melancholia. Each level of hostile tension is marked by different rates of suicide, and there can be postulated a significant relationship to the rate of homicide.

Starting with this concept, there was presented an analysis of available data and literature gathered from vital statistics—civilian and military—occupational sources, and insurance companies.

Considerable information is available on the choice of agents, the personality type of persons likely to commit suicide, and the distribution of rates in relation to season, hour, and geographic location. There is also information concerning family size, marital state, migration, socioeconomic level, and cultural factors.

The design for a systematic study of suicide along epidemiological lines, however, would have to go further. As a necessary first step, it would be centered on the biological gradient, which means suicidal states and attempted suicide, and would endeavor to verify the various causative factors and the various levels of severity of hostile tension. The relative frequency of suicidal attempts in various forms of mental disease would be studied. There would also be a study of the members of the families where suicide or attempted suicide has occurred. There would, finally, be a comparison with a controlled series with a select, nonpsychiatric condition.

The implementation of such a study appears to be within reach with present facilities and with such facilities as might be developed through public health efforts.

DISCUSSION

DR. F. L. W. RICHARDSON JR.: Have you taken into account the opposite of the point of view, namely, that the mental disturbance may be primary, influencing migration, as well as suicide?

DR. JOHN E. GORDON: Do you ask what is the correlation of mental disease, suicide, and migration?

DR. F. L. W. RICHARDSON JR.: Yes. Mental disease may be primary, having led to migration in the first place, and thus have selected out of a population those more prone to suicide.

DR. JOHN E. GORDON: In other words, which is the hen, and which is the egg? I believe it possible in migrations of people to determine effectively a control group representing ordinary immigration and a group immigrating under stress. One factor would be the time element. Emigration during the Irish potato famine could be compared with migration in times of plenty. The data to which I referred showed a regularly recurring phenomenon; in other words, irrespective of nationality, country of origin, and time of immigration, the result in terms of suicide was regular. In the Chicago experience, suicide rates were higher for immigrants than for natives of the country of origin except for the Canadians, where it was in the proportion of 1:6.

DR. LEO ALEXANDER: The question of the social acceptability of suicide seems to determine its incidence in the two main age groups. In Europe and China, outstanding loss of face or prestige makes suicide socially acceptable, particularly in the young adult or middle-aged groups. Suicides among aged people, on the other hand, were hardly heard of in China or Europe. In this country suicide among old people is socially more acceptable, as a way out of a difficult situation.

Another point of interest for investigation is the question of the nature of the introjected image, which the patient hates so much that he kills himself to kill it, and whether its general nature varies in different cultural groups.

Dr. Lindemann's statement that there is no sharp line between neurosis and psychosis, but, rather, that it is a matter of degree, is a great contribution. Responsiveness to certain physical treatments, for instance, does not run along the border between neurosis and psychosis, but cuts through both groups.

I should like to ask whether the Denmark data have been broken down into age groups.

DR. JOHN E. GORDON: The data from Denmark illustrate a point which I hope I made clear in my discussion, namely, that rates for suicide or any disease are subject to material variations. The fact that high rates exist at a given time, or in some places, does not indicate that the cause of that high rate is the same in all instances. The explanation may be a difference in host or a difference in environment. In Denmark, the dominant age group attacked before the war was the older adult one, and the rate was higher for men than women. During the war the increase of suicides was among young women, but for young men rates were lower than usual. An interesting counterpart is seen in military practice, where rates for suicide are regularly less in time of war than in peacetime for equivalent age groups. This relation has held in the last three wars. It is an interesting commentary on the frequency of suicide that under such conditions, when stress is great, suicide is less.

DR. ERICH LINDEMANN: But war offers alternating opportunities for violent action. That is the question Dr. Alexander referred to—the intrapsychiatric process related to the final discharge of violent action. One would have to postulate an incorporated other person. A variety of mechanisms is operative. The relation of the need for violent action to the restraining forces will reach a critical point. We shall have to list all the restraining forces under normal circumstances: the support of fellow men; the feeling of enjoying the respect of the group. Old people are "discarded" in this country and lose a meaningful role in the population. They find themselves without support and without opportunities for discharge of legitimate aggressive behavior. One will have to consider the explosion of violence at the critical level of hypereridism as one variety of adjustment to a powerful stress situation.

As to the relation of homicide to suicide, the fluctuations in suicide with the season and with other variables are parallel to the fluctuations in homicide. There is evidence that the two

forms of discharge of violent action may be related. There is a difference between the white and the Negro population in the ratios of suicide and homicide. There is more homicide among the Negroes and more suicide among white persons.

DR. A. WARREN STEARNS: I have been much interested in this discussion. When I started working in the field of psychiatry, 40 odd years ago, everyone was interested in heredity, and we had eugenics workers from Cold Spring Harbor. If anything wrong was found in a relative —prostitution, suicide, burglary, insanity, or rheumatic fever—it was used to explain the patient's difficulty. Later, mental tests came in, and we had great hopes for psychology. We had replaced our clumsy rule of thumb methods with exact procedures. But psychology did not solve our problems. In some ways it made us more confused. Then endocrinology had the stage for a while, and everyone went to New York to see what Dr. Timme was doing. This, too, has gone "the way of all flesh." The chemical era was upon us, and all disease seemed biochemical in origin. Then psychogenesis, whatever it is—chaos, I would say—engulfed us and drove us old fellows from the stage, but without changing the picture a great deal. Now it is gratifying to have the epidemiologists come in, and we look forward to their achievements with great hope.

I agree in general that there is a sort of basic level at which suicide will take place. I look upon it as a stimulus and response, like a reflex. Something pulls the trigger. In ordinary times the level is probably high in mental disease, the stimulus coming from within. During times of stress there are added to that basic level situational factors, and the stimulus comes from without.

I do not believe suicidal attempts can be compared with suicide. While they overlap, they are quite different. For instance, in attempts at suicide, iodine is the method of choice, but I do not recall having seen a death from iodine poisoning. Furthermore, the number of women is very high in cases of attempted suicide and relatively low in successful suicides. Attempts are more histrionic.

DR. SIDNEY COBB: Dr. Stearns spoke of the changes and developments in the field of psychiatry. We might examine what has happened in the field of epidemiology which has led to this meeting of the minds. As Dr. Gordon pointed out, the study of diseases as a mass phenomenon began with the communicable diseases. In recent years epidemiologists have profitably applied their methods to the examination of various chronic diseases, such as multiple sclerosis, rheumatic fever, and cancer. Even trauma has been studied as a mass phenomenon. Tonight, these two disciplines have joined hands, and one may well hope that it will prove to be a fruitful marriage.

DR. JOHN E. GORDON: In my introduction I gave attention to the three ways by which disease may be studied. A clinical approach is the point of departure. Contributions also arise through the experimental method; others, by way of the study of groups, which is epidemiology. My aim this evening was not to present epidemiology as a substitute for either of the other two general methods of investigation, but to show that there are three ways of approach, that each has its particular value, and, finally, that full accomplishment or knowledge of any one disease is likely to come from use of all three.

James L. Poppen, M.D., Presiding

Regular Meeting, March 22, 1951

The Sexual Function in Paraplegics. DR. HERBERT S. TALBOT, Veterans Administration.

The sexual function comprehends three major activities—psychical, gonadal, and neuromuscular. In spite of the occasional finding of testicular atrophy, it is probable that the first two are not significantly altered as a result of spinal cord injury.

The present study covers data on the neuromuscular aspect of sexual function gathered in a study of 408 paraplegic and quadriplegic patients. Of these patients, 46% had erections in response to local stimulation, and 20%, in response to psychical, as well as local, stimulation; 34% had no erections at all. About one-third of those having erections were able to have intercourse, and 7% of these, in turn, were fertile. Return of these sexual functions usually occurs within six months after injury.

The popular belief that all such patients are impotent is, therefore, unjustified. Careful study of the individual patient, with conditioning of the reflexes of neuromuscular sexual activity, may result in the development of a reasonably satisfactory level of sexual activity, so contributing significantly to his rehabilitation and well-being.

DISCUSSION

DR. JAMES L. POPPEN: Has anyone an idea about the relation of sexual function in disturbance of the sympathetic nervous system to that in lesions of the spinal cord? Dr. White, would you care to discuss this?

DR. JAMES L. WHITE: I have not made a special study of sexual disturbances following injuries to the spinal cord, but from what is known of the neurogenic control of sexual function in the male, I believe one might expect the effects to be as follows:

As long as the sacral segments of the cord and their distal connections are intact, erection on a reflex basis should be preserved. If the central connections are severed, psychical (erotic) stimulation of erection will be lost, but local stimulation of the penis may still be effective. The sympathetic centers in the lower thoracic and upper lumbar segments of the cord control the passage of spermatozoa in the vasa deferentia and their ejaculation through the prostatic portion of the urethra. It is possible that this mechanism may also function in a coordinated reflex fashion with the sacral erectile mechanism. Under these circumstances, successful impregnation of the female and conception could still take place, even in the absence of any descending impulses from the brain. If the sympathetic centers of the cord are destroyed, erection can still take place, but with the loss of ejaculation of viable spermatozoa.

Headache as an Epileptic Manifestation. DR. BENJAMIN MATZILEVICH, Worcester, Mass., and DR. JEROME K. MERLIS, Veterans Administration.

Of 500 veterans with epilepsy, 38 gave a history of aura or prodrome of head pain. Thirty-three of these patients gave evidence of having acquired epilepsy. There was no relation to localization of brain damage or to the clinical form of seizure. In one patient with a normal interseizure electroencephalogram, the slow intravenous infusion of 5% metrazol® (pentylenetetrazole U. S. P.) produced seizure discharges, which began after injection of 2.5 cc. and continued about two minutes after the infusion was stopped. The typical headache began about one minute after the onset of seizure discharge and continued approximately one-half hour after the electroencephalogram returned to normal.

Of 25 patients who were followed up, 19 showed definite improvement in both headaches and seizures during anticonvulsant medication.

Ten patients with paroxysmal, nonmigrainous headache without seizure manifestation but with abnormal electroencephalograms were also studied. In two of these patients the electroencephalograms were normal during headache-free periods but showed seizure discharges during headache. One of these patients was treated with diphenylhydantoin, with considerable benefit.

It is concluded that, although head pain is not a true aura, i. e., a sensation produced by discharge in a specific area of the brain, in some cases cerebral discharge may participate in the chain of events producing head pain. In such cases anticonvulsant medication may be of value.

DISCUSSION

DR. JOSEPH M. FOLEY: It is general experience that patients with epilepsy, especially posttraumatic epilepsy, are likely to have headaches. The concept that headache without clinical evidence of epilepsy can be regarded as a seizure is too important in the practical management of patients to be accepted without unequivocal proof. The response of such headache to anticonvulsant drugs is not sufficiently determinate to allow any conclusions. In the experiment reported by Dr. Matzilevich, did the headache precede or follow the development of the abnormal waves in the electroencephalogram?

DR. BENJAMIN MATZILEVICH: After infusion of 2.5 cc. of metrazol,® a few slow bursts appeared. The pain came suddenly after injection of 3 cc. and lingered for about one-half hour, whereas the electroencephalogram returned to normal in a few minutes.

Veteran Status as a Complication of Psychotherapy. Dr. Morris H. Adler and Dr. Phillip H. Gates, Veterans Administration.

Psychotherapy with veterans, in addition to all the usual problems, has difficulties referable to the patient's special status of being a veteran, with its concomitant compensation system. The military experience is used by some to gratify unconscious wishes. This confuses the real situation with the unconscious impulses and threatens the ego with a loss of mastery. Successive surrender of ego roles because of guilt and anxiety leads to immature levels of functioning. Condoned aggression in the service is followed by condoned passivity as a veteran. The latter encourages regression, especially if a disability rating is taken to mean the sanctioning of unconscious gratification in the military service. Both the public and the veteran use medical rehabilitation to express attitudes unrelated to treatment. The veteran is considered hostile and aggressive by the public and kept in check by the payment of tribute. The public expiates its guilt for sacrificing the serviceman on the battlefield by now treating him with preferential favoritism. Finally, the veteran with a dependent character structure uses his compensation and medical rehabilitation in a futile attempt to make up for all previous deprivations.

Program of Teaching a Psychodynamic Orientation to Resident Physicians in Medicine. Dr. Sidney Kligerman, Veterans Administration.

The author presented in narrative form some of the various experiences in the development of the teaching program indicated in the title. At first, joint medical-psychiatric conferences alone were used, but these were found to be unsuccessful because of discrepancies in the level of training in psychiatry between medical and psychiatric residents and staffs. After two years, a psychosomatic section, consisting of the author and four psychiatric residents, was organized and incorporated into the medical service. Much was learned by medical and psychiatric residents of psychosomatic illness, and also much of value in patient-internist and internist-psychiatrist relationships. After six months of work in the psychosomatic section, and lacking psychiatric residents, the author continued with the teaching program while remaining on the medical service. Seminar groups of medical residents, on a voluntary basis, have been meeting regularly with the author to discuss concepts of psychosomatic medicine and interviewing techniques. These seminars are conducted according to a semidirected associative procedure. Essentially, this involves the selection of a common ward problem as subject and the author's participation, as moderator, in stimulating the group members to associate to the question under discussion. A result of seminar meetings has been the active psychotherapy of medical patients by a number of group members, under the author's supervision. As yet it is too early to evaluate this program in detail. However, its effect can be observed in greater awareness on the part of the medical residents of the "person" with illness. This was the intended goal of the program.

DISCUSSION

Dr. Joseph M. Foley: Dr. Kligerman has presented interesting material to support the usefulness of a special approach in teaching a psychodynamic orientation to medical residents. Many medical schools are now using much the same approach. I should like, however, to submit for discussion the proposition that such an approach may be not only disadvantageous but even dangerous. How far can the half-trained physican be entrusted with the responsibility for stirring up unconscious mechanisms without getting himself and the patient in trouble? This program of Dr. Kligerman's is dependent upon the intricacies of psychoanalytic doctrine, for the proper use of which psychoanalysts themselves require years of special training. The medical resident, cited by Dr. Kligerman, who treated all asthmatic patients routinely with rectal administration of aminophylline needed something more than a knowledge of psychodynamics. He needed, in fact, the kind of critical experience which has taught the good physician that asthma cannot be treated "routinely" with anything. A man at a resident level who had failed to see this was unlikely to make intelligent use of any psychodynamic orientation that was given him. It is possible that he will never make a rectal examination or give rectal medication without thinking of it as a form of sexual assault. The emphasis on diarrhea as a manifestation of hostility and aggression makes me pray that the medical residents who have accepted this

interpretation never find themselves faced with the stark reality of an epidemic of bacillary dysentery or cholera. There may be more hostility and aggression than they can handle in such a situation.

Programs of this sort are based on the supposition that physicians who know nothing about, or even disbelieve in, psychoanalytic orientation are unprepared to handle the psychological problems which confront sick people in the course of their disease. This supposition has never been proved, and I consider it dangerous for psychiatric teachers to proceed upon it.

DR. SIDNEY KLIGERMAN: I deliberately chose that particular resident as an example. Of course, in some ways, he is a confused boy. He has been in this program for almost two years. He is one of the better senior medical residents on a highly competitive service. Just the other day, one of the psychiatrists disagreed with him on a psychiatric consultation concerning one of the resident's patients. As it turned out, the resident was correct. Consider the number of men who go into private practice and who treat patients by means of reassurance, or some such form of haphazard psychotherapy. At least, a man who gets this type of training has some idea of the problems and dangers he may run into.

The questions Dr. Foley has raised are pertinent and deserve consideration. I think, however, that he is raising too many shadows to fight.

DR. LEO ALEXANDER: The difference between Dr. Foley and Dr. Kligerman can probably be resolved. We all must look out that we are not one-treatment doctors.

The veterans are as difficult to treat when they do not receive compensation as when they do. It is dangerous and shallow reasoning to overemphasize the financial gain. In some patients the defenses against dependence are so strong that they refuse compensation against their own best interests. One patient whom I have been seeing for four years refuses to ask for any compensation. Another patient is very uneasy about receiving money. There is a great deal of instructive control material in private practice, where one usually sees the patients who do not receive compensation.

I agree that evaluation of the results of psychotherapy is very difficult, because of the intangible factors involved. I have given some thought to devising a quantitative scale, by which the results could be expressed in a graph, similar to one that I have devised for the evaluation of the neurological examination. It is obvious that the problem in psychiatric illnesses is much more difficult and that a great deal of thought would have to be given to the scored items. I do feel that the Rorschach test is confirmatory evidence concerning the depth and the quality of improvement.

Problems in Evaluating the Results of Psychotherapy. DR. WILLIAM F. MURPHY, Veterans Administration.

Although an enormous amount of time, money, and energy is being channeled into the field of psychotherapy, there are practically no reports in the literature that would indicate the results of these efforts. With the majority of reports, terms and criteria are inadequately defined. This is in part because the less severe the psychiatric illness, the more difficult it is to evaluate results.

A primary requisite is that the method of psychotherapy which is being evaluated be properly defined and described. Psychotherapy has come to mean practically any contact with a patient. Even in psychoanalysis, its technique varies from one analyst to another, and in the field of other therapies the variation is considerably greater. The experience and aptitude of the therapeutist play an important role in evaluating a therapy, and at times it is difficult to differentiate between the evaluation of a therapy and the evaluation of a therapeutist. The type of patient and the setting in which he is treated are also of importance. A therapy yielding excellent results in the case of university students may be useless in connection with pensioned veterans. A hospital setting in itself may nullify attempts at therapy. The longer the duration of therapy, the better the chance that outside factors will influence the result. The problem of a control series might readily be combined with research in the field of group therapy. It is impossible to separate an evalution of the results obtained from the goal that is set. The conclusions of the physician who is treating the patient as to whether or not this goal has been reached can be considered as one estimate of the results of therapy. Transference cures, flights into health, and other factors obscure the results and make the patient's opinion unreliable. At times, esti-

mation of results may be confused with difficulties in handling situational problems which cannot be altered. The opinions of friends and relatives are valuable as a group and unreliable individually. The opinions of physicians without psychiatric training are worth little, but the opinion of a family physician is fairly reliable. The honest impressions of the therapeutist may be distorted by wish fulfilment, but are on the whole as accurate as any. Similar problems are encountered by educators, who must evaluate the progress and the abilities of a student by grading him.

In spite of philosophical problems and subjective uncertainties, it is possible in most cases to delineate certain spheres in which improvement can be evaluated with some measure of objectivity. These are as follows: 1. Disappearance or lessening of symptoms. This is not significant unless the symptoms have been present for a long time and do not recur or reappear in a different form, including psychopathic acting out and withdrawal from society. 2. Absence of further need for therapy, with freedom from a parasitic attachment to physician, spouse, or parent. 3. The development of insight. This refers not only to an intellectual understanding of the relationship of the patient's symptoms to repetitive conflicts in the past, as well as the present, but also to an emotional conviction of the reality of these relationships. 4. The ability to work through and utilize this insight and to act more in accordance with the reality situation and with greater freedom of choice. 5. The ability to do without the secondary gains which the illness has provided. One hundred per cent success in achieving all these goals is seldom obtained outside of psychoanalysis, but an estimation of success or failure with every patient should be made in all these fields in evaluating any therapy. The use of psychological test batteries before and after therapy is of value, but there are many pitfalls, and conclusions in this field usually are just as subjective as a clinical examination by the psychiatrist.

CHICAGO NEUROLOGICAL SOCIETY AND ILLINOIS PSYCHIATRIC SOCIETY

Joseph A. Luhan, M.D., *President of Chicago Neurological Society, in the Chair*
Joint Meeting, May 19, 1951

Some Sources of Error in Neurological Diagnosis: Presidential Address. Dr. Joseph A. Luhan, Chicago.

Time and Culture Concepts in Schizophrenic Patients. Dr. Celia Kirson, Manteno, Ill.

The degree of disorientation among schizophrenic patients has been considered mainly in terms of their ability to identify an objective, calendar-like present. This approach to the disorientation of schizophrenics implies that they deviate from the collective, objective conception of time as characterized in the given culture. From the subjective standpoint of the schizophrenic, however, he becomes a tridimensional being, and his conception of time—of past, present and future—ranges from his recall of the past to his types of anticipations in the future.

In the acute, confused breakdown episode, the schizophrenic, by losing a temporal sequence and logical interval, frequently cannot recall his acute breakdown because he cannot reconstruct chaos or experiences which are too painful to face. Though his subconscious responses may exist, the acute breakdown indicates that conditions which are too chaotic or too painful in his past cannot become part of his conscious present.

Regression as pertinent to the past cannot be a mere reversion to an infantile mode of behavior because these responses include his present outlook and conflicts, for the present personality has to experience a culminating series of traumas which he cannot reconcile or solve before he resorts to past fixated responses. These fixated responses, in turn, minimize the significance of his present.

The schizophrenic's inability to reconcile his actions with the present is further complicated by the fact that he judges time in terms of his reactions to fantasy, that he loses an inner feel for time when he withdraws his affect from environing objects, and that he has a personalized, and concrete orientation to time.

Since the schizophrenic frequently loses a capacity to aspire to future goals, his future becomes obscured, or even disappears. His orientation to the future is expressed frequently in his delusions. These delusions may reveal elements of cosmic catastrophe and the ending of time or may show fantasies of personal fulfilment; these varying delusions, then, indirectly provide clues for the potential improvement of the given schizophrenic.

In short, the temporal approach to schizophrenia cannot be complete by a description of symptoms in the static present, namely, the period of diagnosis, or by creating analogies with a past infantilism. It requires an understanding of the schizophrenic's development, outlook, and conflicts within a culture context.

Studies in Infanticide in Psychotic Women. Dr. Charles Shaiova and Dr. Marianne Chermak, Manteno, Ill.

A series of 12 cases were studied: These consisted of women who had killed their children at times varying from six weeks to two and one-half years after the birth of the child. It was noted that preference existed in the sex of the child killed.

The patients were studied with reference to their relationships to mother, father, siblings, husband, mother-in-law, and offspring. In addition, the patients were evaluated psychologically by a test battery consisting of the Wechsler-Bellevue, the Rorschach, the Murray Thematic Apperception, the Bender Gestalt, and the Figure-Drawing test.

Definite patterns were seen with regard to the sex of the child, the mode of killing, and the complicated interpersonal relationships these persons endured.

Functional Organization of Some Bulbospinal Systems. Dr. Patrick Wall, Chicago, and Dr. Jerome Y. Lettvin, Manteno, Ill.

Localized Destruction in Pons Involving Central Tegmental Tract and Medial Lemniscus: Report of a Case. Dr. Jerome Y. Lettvin, Manteno, Ill., and Dr. Patrick Wall, Chicago.

NEW YORK NEUROLOGICAL SOCIETY AND NEW YORK ACADEMY OF MEDICINE, SECTION OF NEUROLOGY AND PSYCHIATRY

Harold G. Wolff, M.D., *President, New York Neurological Society, Presiding*
Joint Meeting, May 8, 1951

Sarcoidosis with Involvement of the Central Nervous System. Dr. Willard H. Pennell (by invitation).

Sarcoidosis (Boeck's sarcoid) was reported to involve the central nervous system in 41 cases. In 17 cases with autopsy the brain, meninges, pituitary gland, and hypothalamus were found to be the commonest sites. The choroid, optic nerves, and dura revealed lesions in other cases. Because of the variety of lesions, the range of clinical symptoms was wide. Diabetes insipidus was a prominent symptom in 12 of the 41 cases, and an adiposogenital syndrome was present in 4. In five of this series autopsy was performed and disclosed lesions of the pituitary and hypothalamus. Headache, confusional psychoses, and various paralyses were seen, and in four cases one or more generalized seizures occurred. Cerebrospinal fluid studies were available in only 16 cases, and an increase in cells and protein were the common findings. The spinal fluids of patients with pituitary lesions were essentially normal.

Colover (*Brain* **71**:451, 1948) reported the case of a woman with thickening of the arachnoid in the posterior fossa, biopsy of which revealed sarcoidosis. The sugar content of the spinal fluid was repeatedly low (17 to 40 mg. per 100 cc.) for many months. She recovered without specific therapy, and no organisms were obtained.

Two additional instances of sarcoidosis of the central nervous system with low sugar contents of the spinal fluid have been encountered at the New York Neurological Institute. In the first case the patient lived seven years after the onset of symptoms of headache and lesions of the posterior fossa and had a low spinal fluid sugar (28 and 32 mg. per 100 cc.) for many months. In the second case iridocyclitis was followed several months later by difficulties in urination and staggering gait. Multiple examinations of the spinal fluid over a period of 10 months revealed an increase in cells, protein and sugar, the level of the sugar ranging from 10 to 40 mg. per 100 cc. No organisms were found over this period, and there was no significant change in the

patient's neurological status. Although in neither case was microscopic study of the nervous system carried out, the diagnosis seemed well established by the clinical course and biopsy findings.

Sarcoidosis may involve any part of the central nervous system, producing a multiplicity of symptoms, of which diabetes insipidus is a not infrequent one and should suggest the possibility of the disease. The three cases reported, with a low sugar content of the spinal fluid and the long clinical course, suggest that the disease is caused by an infectious agent.

DISCUSSION

DR. H. HOUSTON MERRITT: Dr. Pennell has called attention to a difficult diagnostic entity. Sarcoidosis is rather uncommon, but it presents so many features similar to those of tuberculosis that in many cases the differential diagnosis is almost impossible. This applies not only to the lesions in the central nervous system but also to those in the lungs and elsewhere in the body. In the two cases reported by Dr. Pennell in which there was involvement of the meninges with lowering of the spinal fluid sugar the diagnosis has not been confirmed by autopsy. Results of all the other diagnostic tests establish the diagnosis, particularly the positive Kveim reaction and the biopsy findings in the lesions. As Dr. Pennell points out, the low sugar of the spinal fluid, together with a spinal fluid formula which is almost identical with that of tuberculous meningitis, makes it almost impossible to differentiate the two conditions. In fact, I believe that some of the cases that were reported as instances of cured tuberculous meningitis in years past were probably instances of this disease. The low sugar content of the spinal fluid is strong evidence in favor of an infectious agent and is one more bit of evidence in support of the hypothesis that sarcoidosis is an infectious disease.

Dr. RICHARD M. BRICKNER: Were the control blood sugars normal?

DR. WILLARD H. PENNELL: Yes.

DR. FRED PLUM: In the presence of sarcomatosis of the meninges or glioma with a high cell count, is the sugar content not lowered?

DR. WILLARD H. PENNELL: To the best of my knowledge, the sugar is not lowered with the gliomas.

I do not want it to be taken that this low sugar level is diagnostic of the disease. Spinal fluid findings have rarely been reported in cases of sarcoidosis in the literature, but in a few the sugar content was normal; so the presence of a low sugar level is consistent with the disease, but its absence does not rule out the diagnosis.

Cerebral Angiography in Subdural Hematoma. DR. JOSEPH M. STEIN (by invitation).

Fourteen patients suspected of having a subdural hematoma, who presented other major conditions and problems in differential diagnosis, were studied by percutaneous cerebral angiography. In seven patients the presence of the subdural hematoma was verified. In six of these the angiogram revealed a unique pattern in the anteroposterior arterial phase—and a vascular space between the vascular tree and the cranial vault. For the seventh patient the film was unsatisfactory because of motion. This unique pattern has not been seen in any other condition; it has been described in cases of epidural hematoma.

Of the seven patients without subdural hematoma, angiographic study revealed a neoplasm in one (verified at autopsy) and an intracerebral mass in another (verified surgically as a chronic intracerebral abscess). The others recovered, with subsequent pneumoencephalograms all without evidence of mass lesions. Thus, there was excellent correlation between the angiographic findings and the subsequent course of the illness. Cerebral angiography is proposed as a specific nonsurgical method for the diagnosis of subdural hematoma, for the exclusion of the diagnosis of subdural hematoma, and for the differentiation of subdural hematoma and other intracranial lesions.

The author suggested the following references: Wickbom, I.: *Acta radiol.* **32**:249-258, 1949. Green, J. R., and Arana, R., *Am. J. Roentgenol.* **59**:617-650, 1948. Lima, P. Almeida: *Cerebral Angiography*, Oxford University Press, London, 1950.

DISCUSSION

DR. SAMUEL BROCK: This is an important practical contribution. It may well be that this diagnostic method is more important than pneumoencephalography in selected cases; it is particularly important in a hospital of the general nature of Bellevue, which admits nameless waifs who, for one reason or another, cannot give a history. Time will decide whether this investigative weapon will take precedence over pneumoencephalography. It behooves us to use this test and assess its ultimate value.

DR. HOWARD DUNBAR: Were any complications associated with this procedure? Was the bowing of the anterior cerebral artery to the other side, which was present on all films, taken into consideration? Was an increase in intracranial pressure demonstrated?

DR. JOSEPH M. STEIN: As to complications, there were two deaths in the series—one that of a man with a neoplasm, which autopsy revealed to be an extensive one involving both hemispheres; the other, that of a patient who had undergone evacuation of a subdural hematoma; he had a stormy course for 10 days and then died. Autopsy revealed diffuse edema of the brain. The first patient whom I demonstrated in the series was discharged in good condition and then returned to the hospital after another head injury, at this time with persistent aphasia. The angiographic study was repeated bilaterally, demonstrating a normal pattern. This procedure was followed by pneumoencephalography, which showed no evidence of a mass.

In regard to the bowing of the anterior cerebral artery, I feel that this is a nonspecific and inconstant feature. One of the patients in this series had the avascular space, with no distortion of the anterior cerebral artery. Unfortunately, the roentgenogram was not suitable for reproduction.

An increased intracranial pressure was present in some cases and not in others.

DR. HERBERT PARSONS: I should like to ask Dr. Stein whether he found it easier to make angiograms than burr holes; there are complications in obtaining arteriograms, and I wonder whether the hazard is as great as in making burr holes.

DR. JOSEPH M. STEIN: The procedure has not been carried out routinely on all patients suspected of having subdural hematoma. These patients are not in coma; their treatment is somewhat elective, and many of them had serious complications in other fields, among them pulmonary tuberculosis. One girl was in diabetic coma; others had severe hypertension; many were alcoholic and in a deteriorated state—all patients on whom we did not want to operate immediately if we could help it; it was these patients, who presented problems in differential diagnosis, on whom we carried out the procedure. As to the ease of the procedure my colleagues and I have been doing for a year and a half; we have fairly smooth teamwork and find no great difficulty. The complications do not fall well within the scope of the paper. I mentioned those which occurred in this series. We have had complications in other patients which I cannot discuss here, but in our opinion the incidence of complications was not great enough to preclude use of the method. In this series of patients we found the procedure highly valuable.

DR. PETER G. DENKER: Did you say that many of these patients had a general anesthesia before the procedure? Does that not involve a considerable risk, especially when so many of the patients were severely ill with various medical conditions, in addition to the neurological lesion? I also wonder whether the angiography and anesthesia do not involve a greater risk than does the making of a small burr hole in the skull to determine the presence of a hematoma.

DR. JOSEPH M. STEIN: Ten of 14 patients were given thiopental (pentothal®) and we found no great hazard in this respect. The patients in whom a subdural hematoma was demonstrated were operated on immediately, this being another advantage of the method. If the angiographic examination was done some time during the afternoon, the surgeon felt he could do the craniotomy in the late afternoon or evening, rather than wait until the next morning. We did not find anesthesia a hazard. Again, I state that the patients were not in coma; their treatment was elective, and they presented the signs or symptoms of an intracranial mass.

Cinematographic Analysis of Hemiballism. DR. JOHN R. WHITTIER (by invitation).

The medical applications of cinematographic technic to the study of activity were briefly reviewed. The method of graphic analysis of cinematographic records was described, and its application to the study of hemiballism was demonstrated with the aid of lantern slides and

motion pictures of cases collected from cooperating observers. The material to date is not adequate to permit an answer to the question whether destruction of the subthalamic nucleus is the only lesion producing hemiballism. It is concluded, however, that some cases reported as hemiballism differ from those of subthalamic lesions and that closer correlation of hyperkinetic phenomena with pathologic change in the nervous system is possible by use of the graphic analysis of motion picture records.

DISCUSSION

DR. HENRY ALSOP RILEY: I have nothing constructive to add to Dr. Whittier's satisfactory presentation, which I enjoyed. I am glad that Dr. Whittier has been careful in his selection of cases and has limited his conception of hemiballismus to the flinging movements described. In numerous instances in the past there have been various presentations of patients with this type of abnormal involuntary movement who, to my mind, were clearly suffering from chronic athetosis. I think that these movements are altogether different; hemiballismus is an irregular, violent movement in a relatively large arc and does not contain any evidence of a pattern. The characteristic pattern is practically a constant feature in athetotic movements.

DR. MALCOLM B. CARPENTER: As Dr. Whittier brought out, analysis of dyskinesias has presented problems to the clinician and to those who have attempted to review the literature on this subject. The problem of whether hemiballism is a distinct form of abnormal involuntary activity or a type of violent chorea has generated considerable discussion (Wilson, S. A. K.: *Deutsche Ztschr. f. Nervenh.* **108**:4, 1929. Hallervorden, J.: *Zentralbl. ges. Neurol. u. Psychiat.* **73**:724, 1934). Dr. Whittier has shown that a practical distinction can be made, and the pathologic observations appear to confirm this distinction. At the meeting of the American Neurological Association in 1949 (*Tr. Am. Neurol. A.* **74**:79, 1949), Dr. Russell Meyers and associates presented an interesting case of what he thought was hemiballism. In this case he succeeded in ameliorating the "ballism" by section of the U-fibers between Area 4-S and Area 6. Later, I attempted to carry out a comparable procedure in rhesus monkeys with subthalamic lesions produced by stereotaxic methods. I found that ablations of Area 6 contralateral to the activity had no demonstrable effect on the hyperkinesia. However, in those animals in which Area 4 was damaged or infringed upon, paresis without spasticity developed, and the abnormal activity was abolished (Carpenter, M. B., and Mettler, F. A.: *J. Comp. Neurol.*, May 8, 1951). Until the various types of dyskinesias can be distinguished, attempts to deal surgically with these phenomena will probably be unrewarding.

Neurological Manifestations in Sickle Cell Anemia. DR. LEWIS P. ROWLAND (by invitation).

During the 10-year period from 1940 to 1950, the diagnosis of sickle cell anemia was made on 92 patients at the Columbia-Presbyterian Medical Center. Of these, 27 patients (29%) had neurological manifestations at some time during their lives. These manifestations were sometimes due to factors not directly related to this disease, but many were presumably due to the various vascular lesions which have been found to occur in sickle cell disease.

Eight patients had signs of meningeal irritation in 10 separate episodes. In five these signs were the sole or predominant manifestation of a sickling crisis. In the other five, complicating infections were present. Seven patients had convulsive seizures, but in five the seizures occurred on only one occasion, and in the presence of complicating acute states. Three patients had spastic hemiparesis, which had appeared in childhood, presumably on the basis of cerebral thrombosis. Another patient had a gradually appearing hemiparesis associated with other signs suggestive of multiple sclerosis, but vascular lesions may have been present. Two patients had severe muscular weakness and atrophy in the presence of leg ulcers. Five patients had mental retardation. Two patients had ataxia in the absence of anemia or definite localizing signs. Two patients had radicular signs, in one of whom it was associated with infarction of lumbar vertebrae. Two patients had visual symptoms, one having primary optic nerve atrophy. Two patients had porencephaly. Two patients had prolonged periods of coma before death.

While sickle cell disease may cause a variety of acute and chronic neurologic syndromes whether or not anemia is present, the coexistence of the sickling tendency and neurological disorder is not always etiologic, and other causes must be excluded.

DISCUSSION

DR. H. HOUSTON MERRITT: Sickle cell anemia has always been looked at as a rare disease, but Dr. Rowland has found 97 cases in a 10-year-period at the Columbia-Presbyterian Medical Center. This disease occurs predominantly in Negroes. Dr. Rowland found neurologic signs in 27% of the cases. If one analyzes the symptoms in these cases, as he did, one finds that many of them are nonspecific. The signs of meningeal irritation that were present when the child entered the hospital may be discounted as due to meningismus, which may occur in any child with fever. Similarly, the convulsion may be a manifestation of a febrile reaction in childhood. Dr. Rowland has other cases in which it seems more likely that the cerebral changes are related to crises in the nervous system, either at the time of admission or at some time past. He has sounded a word of warning that every symptom that appears in these patients need not be related to the sicklemia, but he has also called our attention to the need of being on the alert for this condition. In the case of the Negro who had a syndrome that practically everyone called multiple sclerosis, the possibility of sickle cell anemia was raised by the typical appearance of the bone infarcts in the roentgenograms. Studies of the blood confirmed the presence of sicklemia. Dr. Rowland has not convinced everyone that this patient does not have two diseases. But the case has made us pause and think, and go over all the cases in which we have made the diagnosis of multiple sclerosis in Negroes to see whether sickle cell anemia has any relation to the diagnosis in these cases.

Psychological Findings in Patients with Vomiting During Pregnancy. DR. WILLIAM A. HARVEY (by invitation).

Twenty pregnant women who represented consecutive admissions for pernicious vomiting to the Lying-in Hospital in New York were studied by the clinical interview method and the Rorschach technique. Control studies were made on 15 patients in the first trimester of pregnancy who were entirely free of any complaint of nausea and who remained so through pregnancy.

The life histories of these 20 patients revealed a ready pattern of gastrointestinal disturbance with vomiting in response to emotional stress. The specificity of the stress experience was described. The patients all presented a serious disorder of sexual life with certain consistent expressions thereof, which were significantly influenced by pregnancy. All the subject patients exhibited well-defined psychopathology of emotion, which was most prominent during the period of vomiting, but which was not relieved prior to the postpartum period.

There was sufficient individual variation in personality organization to preclude the description of any closely delineated type or profile. Although all the subject patients exhibited neurotic symptoms and features, they did not all fall into essentially psychoneurotic diagnostic groupings. Evidence is offered to support the postulate that the genesis of pernicious vomiting is not entirely in the psychological sphere.

DISCUSSION

DR. MARY JANE SHERFEY: I gave the Rorschach tests to these patients, and without exception they all indicated abnormalities. There was no record which one could consider within normal limits. I should like to describe these Rorschach results, on the basis of which the patients could be divided into four groups. The first group comprised patients with the typical hysteria. One cannot tell from the Rorschach test that this was a hysterical neurosis; it could have been a hysterical symptom of any type. A further manifestation in this group, and in all of them, was the remarkably childish, immature personality. The second group may be considered completely immature. These patients were well organized; they were intelligent; they had no neurotic symptoms of any particular sort; they were simply immature. The third group was the most interesting because of evidence of organic brain disorder, which may be epileptoid, or possibly feeblemindedness. The nature of this disorder is not known, and I shall want to pursue this subject by further studies, including encephalography. The fourth group was a very small one, composed of three patients; there were the patients with more complex personalities, including paranoid features, and latent homosexuality and psychopathy.

DR. HAROLD G. WOLFF: Pregnancy is associated with many changes in the endocrine glands. Whaat evidence have you that vomiting during pregnancy has any causal relation to such changes?

DR. WILLIAM E. HARVEY: There is no direct proof. In line with the observations I cited, however, obstetricians tell me that patients who have mild degrees of nausea and vomiting with pregnancy will have this symptom aggravated at the time they would be expected to have their menses.

DR. NATHAN BERCOVITZ: What were the end results in the series? Did all the patients go through their pregnancies, and was the delivery generally normal?

DR. WILLIAM E. HARVEY: Yes. Some of these patients continued to vomit throughout the pregnancy. The more immature and generally inadequate personalities might have their vomiting precipitated by trivial factors, and those with the more complicated psychopathology had severer periods of acute vomiting; but they all went through their pregnancies. One or two underwent treatment in the psychiatric department.

DR. NATHAN BERCOVITZ: What was your therapy?

DR. WILLIAM E. HARVEY: I spent about 6 to 12 hours with them. The therapy was largely supportive. We tried to have the same obstetrician follow them all the way through. Some modifications were made in the hospital management. If they could be relieved of the sexual demands of their partners, that was helpful. No intensive therapy was undertaken during pregnancy.

Effects of Artificially Induced Fever on the Electroencephalograms of Patients with Multiple Sclerosis. DR. THOMAS C. GUTHRIE (by invitation).

The electroencephalogram has been shown to be abnormal in 44 to 62% of persons with mulptiple sclerosis (Zeifert, M.: The Electroencephalogram of Multiple Sclerosis, ARCH. NEUROL. & PSYCHIAT. **60**:376 [Oct.] 1948. Hoefer, P. F. A., and Guttman, S. A.: *Tr. Am. Neurol. A.* **70**:70, 1944). In the light of recent observations on the worsening effects of heat on certain measurable functions in persons with multiple sclerosis (Guthrie. T. C.: Visual and Motor Changes in Patients with Multiple Sclerosis: A Result of Induced Changes in Environmental Temperature, ARCH. NEUROL. & PSYCHIAT. **65**:437 [April] 1951), an experimental procedure has been carried out, using electroencephalographic studies before and during an elevation of body temperature induced by the intravenous injection of 20,000,000 killed typhoid organisms. In five subjects with multiple sclerosis and six with other neurological diseases, rises of 0.8 to 5.4 degrees (F.) occurred.

During the period of elevation of body temperature, the control group evidenced no change in strength of grip, speech, or visual acuity. The electroencephalograms of the six control subjects all showed increased amplitude or scattered or paroxysmal slow wave activity. Four subjects had abnormal records during fever, and two of these showed focal abnormalities. Two subjects in the non-multiple-sclerosis group with abnormal prefever records had normal electroencephalograms during fever.

Of the five patients with multiple sclerosis three showed decreased strength of grip, decreased visual acuity, and increased dysarthria during fever. All five subjects, during fever, had more abnormal electroencephalograms, and two had focal abnormalities.

DISCUSSION

DR. RICHARD M. BRICKNER: Were the adverse effects unquestionably temporary? Some patients with multiple sclerosis in whom fever has been induced by machine (whose cases have been reported either in or outside the literature) have suffered permanent or semipermanent ill effects. Some of these have been severe enough to make one feel that fever therapy administered by machine is contraindicated in multiple sclerosis. I believe that Dr. Ralph Collins, at the Neurological Institute, a number of years ago, also reported the occurrence of transient neurological signs in neurologically normal people after fever therapy.

DR. THOMAS C. GUTHRIE: I think Dr. Collins' report (Collins, R. T.: *Bull. Neurol. Inst. New York* **7**:291, 1938) describes a patient with multiple sclerosis who became worse only during the period of fever. I do not remember any study on normal persons. The effects on multiple sclerosis of intravenous injection of typhoid vaccine have all been transient. I have seen no worsening of motor, visual, or speech function that did not clear after the fever was over.

DR. HAROLD G. WOLFF: These effects are all short, are they not?

DR. THOMAS C. GUTHRIE: Yes.

DR. BERNHARD DATTNER: I should like to point out that fever therapy was for a time an accepted treatment for multiple sclerosis. I recall that a few years ago Dr. Israel Strauss reported here on favorable results of treatment of multiple sclerosis with typhoid vaccine. In Vienna, malaria and typhoid vaccine were used extensively, and the results seemed rather favorable. There is little to prove that fever has an adverse effect, and there are some who are still using typhoid vaccine in the treatment of multiple sclerosis.

Platybasia: Results of Surgical Management in Eight Patients. DR. HOWARD S. DUNBAR (by invitation).

Platybasia, or basilar invagination, is a derangement of the normal spatial relations of the occipital bone and the upper cervical vertebrae. The foramen magnum is displaced upward and the cervical vertebrae upward and forward. The resultant distortion of the brain stem, cerebellum, and cervical and cranial nerves may cause symptoms which are severe and disabling.

Eight patients with severe neurologic symptoms, secondary to platybasia, have had operative decompression by wide removal of the occiput and the arch of the upper cervical vertebrae. The dura was left widely open. There were no operative deaths.

The average duration of follow-up observations was five years. Three patients were improved, and in three others the progress of the disease was arrested. Two patients did not show improvement after operation.

The results would appear to justify surgical intervention in all cases in which symptoms are progressive and disabling.

DISCUSSION

DR. HERBERT PARSONS: I had an opportunity of observing most of the patients reported on by Dr. Dunbar. The most striking operative observation seemed to be the marked indentation of the dura posteriorly, causing an indentation of the contents of the posterior fossa and the upper portion of the cord. One of the symptoms which was not mentioned, but which I recall noting frequently, was pain, not only in the neck and shoulders but even extending down the arms; it is difficult to try to explain why that occurred. It may also be mentioned that platybasia can be demonstrated in a number of normal persons without symptoms if one actually uses the line of measurement from the posterior margin of the hard palate to the rim of the foramen magnum; the odontoid process will protrude slightly above that line in a number of normal persons. Dr. Dunbar is to be congratulated on the operative results in these patients and on his pointing out the importance of the clinical findings.

DR. MILTON KLEBANOFF: Last year there was an interesting patient at the Veterans Administration Hospital at Kingsbridge. He presented an Arnold-Chiari syndrome, oxycephaly, and platybasia, although the platybasia was not pronounced. The surgical treatment consisted of a decompression of the posterior fossa and upper cervical canal.

DR. SIDNEY W. GROSS: In the past few years we have had three cases of platybasia at Mount Sinai Hospital. I wish merely to call attention to one, in which the onset was relatively acute, with symptoms extending over only three months. The patient had increased intracranial pressure, with headache, vomiting, and choked disk. After decompression he made a complete recovery; he has been followed three or four years and has remained well. The other two patients presented cerebellar signs without papilledema; one has made a moderately good improvement, and the condition of the other has remained stationary. It is interesting that Scoville, of Hartford, has advocated, though he has not carried it out on a living patient, the removal of the odontoid process in order to gain a wider decompression of the spinal cord. From the physiological and anatomic standpoint, this would seem advisable. He has done the operation only on a cadaver, and he has found that the removal of the odontoid process through the mouth is feasible.

DR. HOWARD S. DUNBAR: The results as I tabulated them are on an objective basis, the subjective impression having been disregarded. I eliminated all the cases that might have been associated with the rather ill-defined entity of the Arnold-Chiari syndrome. The variations in measurements are well known; I made the point that the malformation itself is unimportant, and that only when neurologic symptoms supervene should something be done.

DR. HAROLD G. WOLFF: You left out all sensory improvement in your results, did you not?

DR. HOWARD S. DUNBAR: Unless I could demonstrate it on examination, I consider it subjective.

Erosions and Acute Perforative Lesions of the Upper Gastrointestinal Tract and Their Relation to Central Nervous System Lesions. DR. BRUCE RALSTON (by invitation).

The material for this presentation was taken from an article written in co-authorship with Dr. Joseph H. Globus (Multiple Erosions and Acute Perforations of the Esophagus, Stomach and Duodenum in Relation to Disorders of the Nervous System, *J. Mt. Sinai Hosp.* **17**:817, 1951).

The relation of multiple erosions and acute perforations of the esophagus, stomach, and duodenum to disturbances in activity of the nervous system has long been known. Cushing (Peptic Ulcers and the Interbrain, *Surg., Gynec. & Obst.* **55**:1, 1932) reemphasized this relation and attempted to show that these lesions were the result of damage to the hypothalamus or its descending pathways and to link chronic peptic ulcer with a disturbance of diencephalic function. A complete review of the experimental and clinical literature (including Cushing's 11 cases) fails to substantiate this conclusion and shows that these lesions of the alimentary canal are most commonly found with diffuse disease of the nervous system, without predilection for the hypothalamus. A study of 544 cases with complete autopsy at the Mount Sinai Hospital over a four-year period shows an incidence of multiple erosions of about 6% in cases uncomplicated by abdominal disease, 85% of these showing evidence of severe pathologic or clinical involvement of the nervous system. In four of the remaining five cases death was from coronary or pulmonary emboli. Although in the great majority the involvement of the nervous system was diffuse, several cases were collected to show that relatively isolated lesions at many levels of the neuraxis may be responsible for the erosions, including the frontal lobe, the cerebellum, and the spinal cord. The erosions have also occurred with the Guillain-Barré syndrome. Similar cases were collected from the literature.

It is concluded that these lesions of the alimentary tract are most commonly seen after diffuse or disseminated disease of the nervous system, without predilection for the hypothalamus. However, relatively discrete lesions produced either clinically or experimentally at many levels, centrally or peripherally, can be responsible for the gastrointestinal lesions. In this limited sense, the nervous system shows "equipotentiality." The finding of multiple erosions or acute perforations during the routine postmortem examination should encourage a careful examination of the nervous system, for in the great majority of cases they serve as pathologic indicators of a disturbance of nervous system activity.

DISCUSSION

DR. JOHN R. WHITTIER: In a large series of subthalamic lesions in monkeys there were associated gastrointestinal ulcers in at least three or four instances. This is a confirmation of what Dr. Ralston has reported. Dr. Carpenter has been doing these experiments and may have something to add.

DR. MALCOLM B. CARPENTER: In studies on the subthalamic nucleus of the rhesus monkey, I placed stereotaxic lesions in that region in about 80 animals. Two or three animals presented erosions of the gastric mucosa at autopsy, but no perforations were noted. Bilateral pallidal lesions were associated with gastric erosions and hemorrhage in several cases and with intussusception of the cecum in one case. I had considered that the gastric erosions associated with bilateral pallidal lesions were due to interruption of the pallidofugal fibers projecting to the hypothalamus.

DR. HAROLD G. WOLFF: Were vagotomies done on any of your animals?

DR. MALCOLM B. CARPENTER: No.

DR. RALSTON: Keller (Keller, A. D.: Protection by Peripheral Nerve Lesions of the Gastro-Intestinal Tract from Ulceration Following Hypothalamic Lesions, *Arch. Path.* **21**:165 [Feb.] 1936) published a paper in which he said he was able to block the formation of the erosions by section of the vagus nerve, but not the sympathetic fibers.

DR. HAROLD G. WOLFF: Did you have any pathologic matter from vagotomized patients?

DR. BRUCE RALSTON: No.

DR. SIDNEY W. GROSS: Dr. Ralston has called attention to these lesions in postmortem material. They can be recognized clinically, however, and gastric ulceration is not an uncommon complication following neurosurgical procedures. When these lesions are recognized early, and in our experience they usually come on the second or third day, and are treated energetically, the patient may recover. I have had two such cases in which the patients, who were doing well, suddenly had a high fever, vomited coffee-colored material, and had abdominal distention and passage of blood by rectum. Both patients were given large amounts of blood; Wangensteen suction was started, and both recovered from this very severe complication.

DR. HERBERT PARSONS: Has any observation been made on the occurrence of this complication in other serious postoperative states? I can recall a number of cases not connected with the nervous system at all in which this has occurred, and I wonder whether there is any correlation.

DR. HAROLD G. WOLFF: For example?

DR. HERBERT PARSONS: I remember a patient who after a radical mastectomy went into shock and died; autopsy revealed an acute perforation. I wonder whether that does not occur with other kinds of serious surgery.

DR. BRUCE RALSTON: Cases have been reported; I remember one in which ulcer followed thyroidectomy (Klemperer, P.: Penner, A., and Bernheim, A. I.: *Am. J. Digest. Dis.* **7**:410, 1940), and it might be postulated that the nerves in the neck passing to the stomach were involved, and a case in which sympathectomy with infarction of the kidney was followed by erosions (Globus, J. H., and Ralston, B. L.: *J. Mt. Sinai Hosp.* **17**:832, 1951). Erosions have been reported with other surgical conditions (Beneke, R.: *Verhandl. d. deutsch. path. Gesellsch.* **12**:284, 1908) and have been produced experimentally in cases of lesions of the thorax and abdomen after both sympathectomy and parasympathectomy (Keller, A. D. *Arch. Path.* **21**:165 [Feb.] 1936. Lium, R.: *Surgery* **9**:538, 1941. Mann, F. C.: *J. Exper. Med.* **23**:203, 1916).

News and Comment

FRENCH PSYCHIATRIST HENRI EY IN MONTREAL

The Board of Directors of the Prevost Sanatorium is proud to announce that Dr. Henri Ey, Psychiatrist-in-Chief of the Bonneval Psychiatrics Hospital of Bonneval, France, will deliver in October a series of 12 lectures on present-day psychiatric problems and two off-schedule lectures on general topics related to psychiatry. The program follows:

Oct. 3 : Psychiatry and the Evolution of Medical Sciences
Oct. 5 : Doctrinal Trends of Today's Psychiatry
Oct. 8 : Organodynamic Conception of Psychiatry
Oct. 10: Evolution of Ideas on Schizophrenia
Oct. 12: The Thought and Personality of the Schizophrenic
Oct. 15: Primary Delusional Experiences
Oct. 17: Chronic Delusional Organizations
Oct. 19: The Neuroses
Oct. 22: Pathological Anxiety
Oct. 24: Hysteria and Psychosomatic Medicine
Oct. 26: Theoretical and Practical Problems of Psychoanalysis
Oct. 29: Necessity and Limitations of Psychotherapy

Off-Schedule Lectures:

Oct. 11: Psychiatry and Morals
Oct. 18: French Psychiatry of the 20th Century

Physicians wishing to attend the lectures should write to the Sanatorium Prevost, 4455 Gouin Boulevard West, Cartierville. An interpreter will be present.

FIRST INTERNATIONAL CONGRESS OF NEUROPATHOLOGY

On Sept. 8, 1952, the First International Congress of Neuropathology will meet in Rome, Italy. The following neuropathologists have been elected honorary presidents of the Congress: Dr. U. Cerletti, Italy; Dr. J. G. Greenfield, United Kingdom; Dr. G. B. Hassin, United States; Dr. J. Lhermitte, France; Dr. O. Vogt, Germany.

Dr. Mario Gozzano, Professor of Neurology and Psychiatry at the University of Rome, was elected president of the Congress. Dr. Armando Ferraro, of New York, was elected secretary-general.

The meeting will last for six days. In the morning sessions, assigned topics will be presented by qualified investigators from various countries. In the afternoon sessions, discussions and individual papers dealing with the morning topics will be presented.

The following topics were chosen at the preliminary meeting of the chairmen of the various national committees, which was held in Paris on May 30 and 31, 1951.

First day: Pathology of demyelinating diseases (five speakers)
Second day: Pathology of vascular diseases (six speakers)
Third day: Pathology in schizophrenia (nine speakers)
Fourth day: Pathology of mental deficiencies (five speakers)
Fifth day: Pathology of senility (six speakers)
Sixth day: Papers and demonstrations of special histopathologic and histochemical techniques

Neuropathologists, neurologists, psychiatrists, and pathologists are cordially invited. The registration fee for active membership to the Congress has been established at $15.

For additional information, please write Dr. Joseph H. Globus, Chairman, United States National Committee, 960 Park Ave., New York.

AMERICAN ACADEMY FOR CEREBRAL PALSY

The American Academy for Cerebral Palsy announces that its annual meeting will be held in Boston, at the Copley Plaza Hotel, on Friday and Saturday, Nov. 16 and 17, 1951. The Friday afternoon scientific session will be open to all interested physicians, and the program will be as follows: The Cerebral Palsy Problem in 1951, Bronson Crothers, M.D., president; Physiology of Motor Learning as Applied to Cerebral Palsy, Frances Hellenbrandt, M.D.; Studies of Gait Patterns of the Hemiplegic Patient, Morton Marks, M.D.; Surgical Methods for Functional Improvement of the Hand in Spastic Paralysis, William Cooper, M.D.; Diastematomyelia, Franc Ingraham, M.D.; Paradoxical Benefit of Cortical Ablation for Selected Hemiplegics, Wilder Penfield, M.D.

Correspondence may be addressed to M. A. Perlstein, M.D., secretary, 4743 N. Drake Ave., Chicago 25.

CENTRAL NEUROPSYCHIATRIC ASSOCIATION

The Central Neuropsychiatric Association will meet in Minneapolis-St. Paul, Oct. 19 and 20, with headquarters at Hotel Nicollet. The Minnesota Society of Neurology and Psychiatry is host to the Association.

SEVENTEENTH POSTGRADUATE SEMINAR IN NEUROLOGY AND PSYCHIATRY, MASSACHUSETTS DEPARTMENT OF MENTAL HEALTH

A review course in basic neurology and psychiatry, under the auspices of the Metropolitan State Hospital and the Psychiatric Training Faculty of Massachusetts, Inc., will be presented in a series of 70 lectures, given every Monday, at 2:00 p. m. to 8:30 p. m., from Oct. 1, to Dec. 3, 1951, and from March 3 to May 5, 1952, at the Metropolitan State Hospital, 475 Trapelo Rd., Waltham, Mass.

All interested graduate physicians should apply before Oct. 1, 1951, by writing to Dr. William C. Gaebler, Supt., Metropolitan State Hospital, Waltham, Mass.

UNIVERSITY OF MINNESOTA CONTINUATION COURSE IN CHILD PSYCHIATRY

The University of Minnesota will present a continuation course in child psychiatry for general physicians and pediatricians from Nov. 26 to Dec. 1, 1951. Dr. Reginald S. Lourie, director of the Department of Psychiatry, Children's Hospital, Washington, D. C., and Dr. J. Franklin Robinson, Director of the Children's Service Center of Wyoming Valley, Wilkes-Barre, Pa., will be the visiting faculty members for the course. Dr. Reynold A. Jensen, Associate Professor, Departments of Psychiatry and Pediatrics, University of Minnesota, is chairman for the course.

Obituaries

WILLIAM LOGIE RUSSELL, M.D.
1863-1951

Dr. William L. Russell, medical director emeritus of the New York Hospital-Westchester Division, formerly psychiatric director of the Society of the New York Hospital, and professor of psychiatry at Cornell University Medical College, died on March 31, 1951, at the age of 87.

Dr. Russell was born in New Brunswick, Canada, July 24, 1863. He received his medical education in the United States, graduating from the Medical Department of New York University in 1885. For several years he practiced medicine in New York City. He was an instructor in medicine and was New York correspondent for a southern medical journal. His first psychiatric experience was in the New Jersey State Hospital, at Morris Plains, N. J.

In 1897 he entered the New York State Hospital service. He took a leading part in transferring by legislation to the medical health officers the responsibility of bringing mental patients from communities to the state hospitals. He was actively interested in the training of psychiatric nurses. He was on the staff of the Willard State Hospital, acting later as medical inspector, and superintendent of the Brooklyn State Hospital.

On July 1, 1911, Dr. Russell came to White Plains, N. Y., as medical director of the New York Hospital-Westchester Division (then known as Bloomingdale Hospital). He enlarged the medical staff and instituted a training program for psychiatrists, which has grown in usefulness to the community and the nation. In addition to advancing all departments of the hospital, he was generously supported in building several buildings for the program therapies of occupational therapy, physical education, and physical therapy. He also built residences for physicians and nurses.

In 1926 he was appointed general psychiatric director for the Society of the New York Hospital. He participated in the planning for the New York Hospital-Cornell University Medical College Center, devoting most of his time to the planning and organization of the Payne Whitney Psychiatric Clinic, which was opened in 1932. He was retired in 1936.

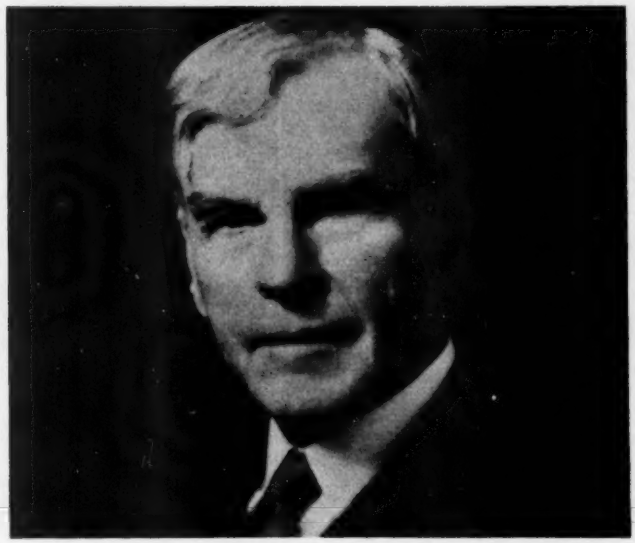
After retirement his life was devoted to committee work and the writing of a book, "A History of the Psychiatric Service of the New York Hospital," which was published in 1945.

Dr. Russell was a member of the American Medical Association, the American Psychiatric Association, of which he was president in 1931; the National Committee for Mental Hygiene; the New York Psychiatric Society, of which he was president in 1914 and 1915; the New York Society for Clinical Psychiatry; the Medical Society of the State of New York; the Medical Society of the County of Westchester, of which he was president in 1919, and the Association for Research in Nervous and Mental Disease; he was a Fellow of the American Board of Psychiatry and Neurology. He was also a member of the National Arts Club.

He was also a member of the Advisory Committee to the National Institute of Mental Health of the United States Public Health Service.

Dr. Russell's many publications in scientific journals showed his broad interests in community needs, and in administration, teaching, and mental hygiene.

In 1888 Dr. Russell married Addie Lewis, who died in 1935. They had four sons. One died in infancy. His oldest son, Paul Russell, a former resident of Westchester County, died at the age of 43. Two sons survive, Dr. Ernest F. Russell, psychiatrist, of Santa Barbara, Calif., and Mr. Blake Russell, of New York.



WILLIAM LOGIE RUSSELL, M.D.
1863-1951

Dr. Russell accomplished much in his chosen field of work. The two psychiatric treatment, teaching, and research centers—the New York Hospital-Westchester Division, in White Plains, and the Payne Whitney Psychiatric Clinic, at the New York Hospital in New York—are living memorials to his character, ability, and ideals of service.

JAMES H. WALL, M.D.

Book Reviews

Spezielle Pathologie der Krankheiten des zentralen und peripheren Nervensystems. By Prof. Dr. Gerd Peters. Price (linen), 56 German marks. Pp. 437, with 214 illustrations. Georg Thieme, Verlag, 47 Diemershaldenstrasse, (14a), Stuttgart O, 1951.

Although to this book may be applied all the trite clichés one finds in reviews: "It meets an urgent need"; "it fills a gap"; the author "did a splendid job," and "he and his publisher are to be congratulated," etc., this is a truly outstanding work. As a matter of fact, there is a great need for such a textbook of neuropathology in German. Whereas there are in English a great number of such good textbooks (Hassin, Weil, Freeman, Courville, Biggart, and others), until now there has been no adequate work in German. Here is such a book. In plan and size it is exactly what the student wants and needs. The author was for years a collaborator of Spielmeyer and Scholz. He has the background and the mettle to produce such a book. It is well written and splendidly edited. The clinical and physiological aspects of the diseases are carefully considered. The presentation is clear and to the point. The whole field is covered adequately. The illustrations are good, sometimes very good. No wonder, the publisher, Georg Thieme, is the German Charles C Thomas. On the negative side: Some definitions would gain if they were more exact; every chapter should conclude with a summary. The author does not take a definite standpoint in controversial issues; he simply lists all the theories, and his own standpoint is never completely clear. The discussion on whether paralysis agitans and postencephalitic parkinsonism are anatomically identical is concluded with a remark that the admonition of Dr. X and Dr. Y "not to mix up these two diseases is not unjustified." The student wants to know the standpoint of the master, which may serve him as a guiding star. If this be dogmatism, make the most of it. It is physiological that in a scientific book from abroad every reviewer checks to see whether the literature of his country is adequately considered. This book is based essentially on German investigations. The consideration given Anglo-Saxon literature is woefully inadequate. It is somewhat peculiar not to find mentioned in a textbook on neuropathology written in 1951 the name of a Hassin, a Weil, a Winkelman, or a Wolf. The Americans Ferraro, Benda, and Bruetsch fare better here: each is mentioned once. Therefore, in some points this book is 20 years behind the time, as, for instance, in the discussion of the subjects of experimental encephalitis, virus encephalitis, and some others. This seeming neglect of Anglo-Saxon literature is understandable, and is due to the war and postwar conditions. It can easily be remedied in the second edition. But, withal, the book is good. It is a worthy monument to German neuropathology and to its great creators: Jakob, Scholz, Spatz, Spielmeyer, the Vogts.

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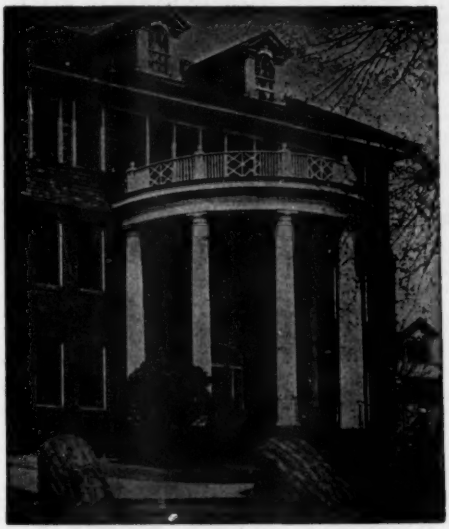

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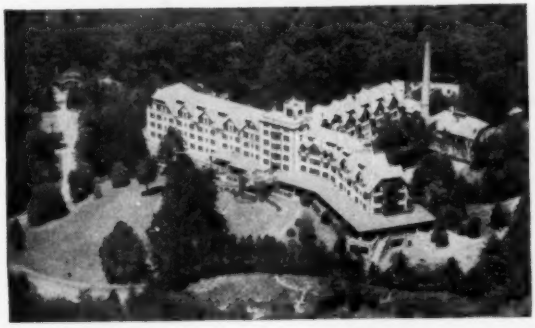

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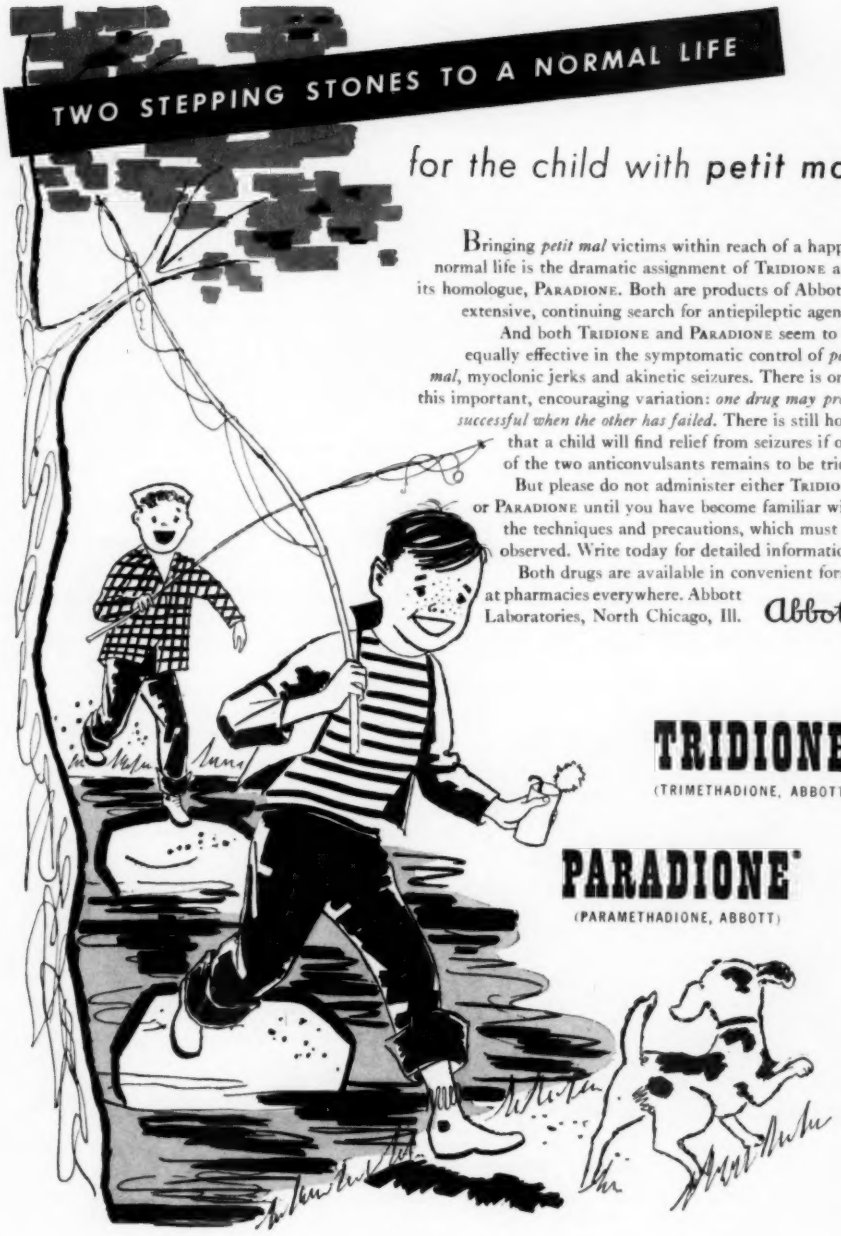

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